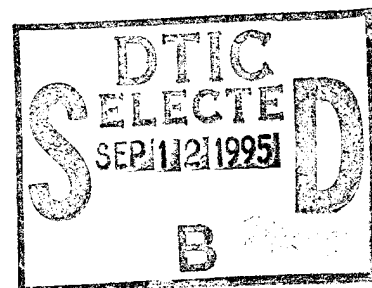


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The Effects of Stress on Judgement and Decision Making: An Overview and Arguments for a New Approach

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14. ABSTRACT (Maximum 200 words)
This monograph consists of an overview of four principal literatures on the effects of stress on human performance, with specific reference to studies of the effects of stress on human judgement and decision making. The four literatures are: Clinical/social/personality (Literature I), ergonomics/human factors (Literature II), psychophysiology (Literature III), and judgement and decision making (Literature IV). The overview led to the following conclusion: Literature I through III are independent and isolated from one another (with the exception of some connections between Literature II and III; they contain essentially no material from Literature IV, which in turn includes essentially none of the material. In deed, there is hardly any work directly related to the effects of stress on judgement and decision making. Thus, there are no secure generalizations regarding these effects. Following the presentation of material that supports these conclusions, I first review the current theories of the effects of stress on judgement and decision making, broadly conceived, from Literature I and III. (Since 1970, roughly 17 theoretically oriented articles have appeared in Literature I and II. Second, I provide brief comments on 10 reviews of the topic. (Ten of the 17 (Continued)

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theoretical articles also provided general reviews.) Third, I briefly describe the numerous and varied conditions and operations that have been used to induce stress in empirical studies. Roughly 13 different conditions have been employed as stressors.) Fourth, the psychological/behavioral functions examined under the aforementioned conditions are described. (I organize the various dependent measures that have been employed into eight categories.) Fifth, empirical studies of specific stressors and psychological/behavioral functions are cross-specific stressors and psychological/behavioral functions are crosstabulated. (A table linking the 13 stressors and the 8 categories of psychological/behavioral functions examined enables the reader to ascertain rapidly which stressors have been studied in relation to which psychological/behavioral functions.) Sixth, the implication of the results are discussed and the status of our knowledge is appraised. (The table alone makes it obvious that our knowledge is scanty, and unevenly distributed over stressors and psychological/behavioral functions.) Finally, in work to be carried out in 1991, I offer a new conceptual framework, address certain methodological issues, and make a recommendation for future research on the effects of stress on judgment and decision making.

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FOREWORD

This report was prepared as an adjunct to the work intended under Contract MDA903-86-C-0142. The original research proposal did not include an intention to prepare an extensive review of research on the effects of stress on judgment and decision making. The review came about during the normal effort to discover what was known about this topic prior to conducting our own project. The report gradually became extensive as a result of discovering the general incoherence and confusion that the author believes, as other reviewers believe (e.g., Levine, 1990), exists in the field. Thus, the review took on a life of its own in the author's effort to construct a coherent statement about the state of our knowledge regarding this important topic. The present report represents the results of that attempt as of 1 November 1990.

More needs to be done; the report is incomplete; it does not pretend to be exhaustive, although, incomplete as it may be, it is the most *comprehensive* review of the topic now available.

The most important section of the report is Part I; Part II consists of the documentation that led to the construction of Part I. A third part, in preparation, puts forward a new approach to this topic.

EDGAR M. JOHNSON
Director

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THE EFFECTS OF STRESS ON JUDGMENT AND DECISION MAKING: AN OVERVIEW AND ARGUMENTS FOR A NEW APPROACH

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PART I

Understanding the foundations of human thinking and the many factors which influence human information processing, such as stress and anxiety, is not a trivial problem. (Committee on Armed Services, 1989, p. 245)

OVERVIEW OF FOUR LITERATURES

In pursuit of knowledge concerning the effects of stress on judgment and decision making I found four relevant literatures. Three literatures focus on three different aspects of stress, but none of these include contemporary work on judgment and decision making. Moreover, the three literatures are largely independent of one another; cross-citations are rare. The fourth literature contains material on judgment and decision making, but offers little regarding the effects of stress. In short, I found almost no research literature that *directly* bears on effects of stress on judgment and decision making.

The three literatures bearing on stress include the following: (a) clinical/personality/social research (Literature I); (b) ergonomics/human factors research (Literature II); and (c) psychophysiological research (Literature III). The fourth consists of contemporary research in judgment and decision making (Literature IV).

In what follows I offer independent evidence that supports my contention that there is very little research that directly links the effects of stress on judgment and decision making processes as currently (1960-1990) conceived. I offer four exhibits to support my argument: First, I offer a current description of the current situation with regard to each Literature (I, II and III), as described by one or more of its foremost contributors; second, I describe current evaluations of our knowledge regarding stress in Literature IV as it is seen by four of its distinguished researchers.

Chapter I
Literature I
(Clinical/Social/Personality)

The best current representation of this field of research can be found in a review by Richard Lazarus (1990), without doubt one of the outstanding researchers in this area. In his 1990 review he presents his current epistemological, metatheoretical and theoretical premises regarding the measurement of stress. In doing so he demonstrates his focus on clinical-personality topics, rather than the specific cognitive activity of interest here (see his Table 1, p. 4). One of his conclusions is particularly worthy of note, thus:

We should abandon the measurement of stress, which tends to be too unidimensional [sic], in favor of measuring the degree and quality of the emotions of daily living. Information derived from such measures could greatly expand our understanding of how individuals handle both positive and negative experiences. (p. 3).

Thus, psychologists interested in stress should devote their energies to "measuring the degree and quality of the emotions of daily living." As a result, "our understanding of how individuals handle both positive and negative experiences" (p. 3) would be enhanced.

It may well be that Lazarus's conclusions are well-founded and that these directions are indeed the ones that those interested in the clinical/personality/social psychology of stress should follow. But pursuing the question of how individuals "handle" both positive and negative experiences is not a question related to current work in judgment and decision making. Unless the cognitive activity implied by the term "handle" is given far greater specification in terms meaningful to those studying judgment and decision, there is little likelihood that Literature I will have an impact on Literature IV.

Further, it is clear that researchers who produce Literature I depend upon the psychometric approach almost entirely; therefore proper test construction is one of Lazarus's main concerns, thus:

Although arguments about how to measure psychological stress are typically based on implicit epistemological and theoretical assumptions, stress measurement has almost never been truly theory driven. The objective of this article is to address several measurement and research issues that derive from my particular metatheoretical concepts of systems thinking, transaction, and process and from my substantive theoretical concepts, which center on appraisal and coping. These issues are illustrated with research on the Hassles Scale. (p. 3)

"Hassles" are not the type of stress envisaged by judgment and decision researchers.

The general ideas, arguments and conclusions put forward by Lazarus may be worthy of consideration by stress researchers. Because his attention

is directed primarily to theories of individual trait measurement by means of psychological tests, however, there is likely little of specific interest to judgment and decision researchers, except, perhaps, as such procedures may help understand individual differences in reference to stressful conditions.

In his 1990 review article, Lazarus cites none of the researchers in Literature II, III, or IV. Although Lazarus is occasionally cited in other literatures, his work is not discussed in any detail.

Chapter II
Literature II
(Ergonomics and Human Factors)

G. R. J. Hockey is among the most prominent contributors to Literature II. He has not only produced a very large number of empirical studies but, in all likelihood, written the largest number of review articles. Perhaps the most thorough of these is his review chapter in the *Handbook of Perception and Human performance, Volume II, Cognitive Processes and Performance* (1986). This review contains over 250 references ranging from the 1930s to 1983. Although Hockey's review begins with a section on "Theoretical Models" and discusses two ("Information-Processing Models" and "Theories of Arousal and Stress"), there is nothing in his treatment of information-processing models to indicate that he has considered contemporary (1960-1990) research in judgment and decision making. His main emphasis is on the computer model of information processing, thus: "The principal components of . . . research of this type are input processes, output processes, storage processes, a central processor, and attention."

In this section there are four references to Broadbent, one to Kahneman's 1973 book on attention, but none to any researchers in the field of judgment and decision making. Nor are there such references (with the possible exception of Easterbrook's 1959 article) among the more than 250 references in the bibliography. Given the thoroughness with which Hockey has covered the literature he deemed germane to his topic, it must be assumed he simply did not consider the J/DM literature to be relevant.

Nor, apparently, did he consider Literature I to be relevant. There is one reference to Janis (1971), one to Lazarus (1976) and two to Mandler (1975; 1979.) (Recall that Hockey's chapter was published in 1986; the latter references would be recent ones if we assume that he wrote the chapter in 1984.) He made essentially no use of this material.

On the other hand, Hockey and others in the human factors area have always been aware of physiological factors related to performance. Thus, for example, his 1986 *Handbook of Perception and Human performance*, chapter contains many references to psychophysiological work, and his *Energetics and Human Information Processing* (Hockey, Gaillard, & Coles, 1986) offers a collection of articles that takes a significant and impressive step toward integrating Literature II with Literature III. This book, as well as Hockey's *Stress and Fatigue in Human Performance* (1983b), provides a rich source of references to studies that link Literatures II and III, as well as a series of high level chapters that also make this linkage. It is too soon to ascertain how much impact *Energetics and Human Information Processing* will have. A search in November, 1990 of the Social Science Data Base and the Science Data Base showed that it had been cited eight times, including one editorial and one book review.

Thus, Hockey's work and that of others in the human factors area offers a clear example that contradicts my assertion about the *independence* of the three Literatures; there is a linkage between Literature II and III. The gateway for the linkage appears to be mainly through the topics of attention and possibly vision, and the concepts of arousal, activation, and effort. However successful the linkage turns out to be, there is little in this work

that reflects the content of Literature IV. Neither the term judgment or decision is indexed in *Energetics*, although "choice reaction time" has six references. In her chapter Clark (1986) indicates that she will "review research dealing with the effects of such [arousal] states on everyday social judgments" (p. 299), but not a single researcher from Literature IV is cited. Her chapter is useful, however, in that it brings research on the effects of mood to bear on cognitive processes, and it may well be that Literature IV will profit from this, but the linkage will have to be more direct than Clark makes it.

Hancock is also a prominent writer in the human factors area, and his more recent work does show some recognition of the existence of contemporary research in J/DM. His *Human Factors Psychology* (1987), published only a year after Hockey's review, contains a chapter by D. Kleinmuntz entitled "Human Decision Processes: Heuristics and Task Structure," that offers a good overview of the field. Characteristically, however, neither Hancock nor the other authors in this edited volume refer to the research in Literature IV described by Kleinmuntz.

There is no acknowledgment of work in Literature I in Hancock's 1987 book. It contains one reference to Lazarus (1966), and one to Lazarus and Folkman (1984), but none to Janis, Mandler, or other contributors to Literature I. Although Hancock's book does not pretend to focus on the effects of stress, and therefore might not be expected to include material from Literature I, three chapters discuss mental work load, and there are 12 references to "stress." The author of one of the workload chapters (Kantowitz) makes the parochial nature of his work clear by bluntly stating that, "I do not see great value in biological indicants of stress or strain" (p. 101). Kantowitz explains this judgment through the use of a metaphor, thus: "The physiological researcher is in much the same position as an electrical engineer who is given a voltmeter to study the operation of an intact computer running a FORTRAN program. It would be very difficult to reconstruct the software from the voltage measurements. My bias is that the optimal way to study behavior is through behavior" (p. 100). Hancock and Chignell's chapter, on the other hand, offers a much broader approach and a general model that does recognize physiological activity as well as cognition more complex than attention.

Chapter III
Literature III
(Psychophysiology)

In 1985 the "Army Research Institute (ARI) asked the National Research Council [NRC] to assess a field of techniques designed to enhance human performance" (Swets & Bjork, 1990, p. 85). The NRC committee found little to recommend with respect to any of the techniques it assessed, but in the course of its work commissioned a review by Seymour Levine on "Stress and Performance" that was published in 1990 by the National Academy Press (Levine, 1990). Because Levine's review carries the prestige afforded by a request from the Army Research Institute, a commission from the NRC, publication by the National Academy Press, and because its conclusions were presented in the article by Swets and Bjork in *Psychological Science* (1990), it offers an opportunity to profit from a report endorsed by authorities in the field on the state of knowledge regarding the effects of stress on performance.

Swets and Bjork (1990) are definite in their conclusions drawn from Levine (1990): "The clear thrust of the evidence from various types of research on stress, from animal studies as well as human studies, is that an individual's uncertainty about impending events and sense of control over them are the main factors in perceived stress" (p. 89). They further observe that "This conclusion is supported by the extensive review paper on stress and performance prepared for the committee by Seymour Levine" (p. 89). It is imperative for our purposes, then, to consider Levine's (1990) review.

First, however, it is important to consider carefully the above conclusion drawn by Swets and Bjork. Note that this remark does two things: first, it provides a description of two stressors (a) "an individual's uncertainty about impending events," and (b) "sense of control over them"; second, it asserts that these are "the main factors in perceived stress." Curiously, the many other stressors, for example, time pressure, sleep loss, physical discomfort from heat, noise, etc. are not mentioned.

It should also be pointed out that the statement says nothing specific about the *effects* of these stressors. The context of what follows, however, implies that when present, these stressors (taken together) will degrade performance in a wide variety of tasks (see pp. 89-90), unless steps are taken toward stress management. Throughout Swets and Bjork's comments on stress the dependent variable is a form of psychomotor activity (e.g., paratroop training). Judgment and decision making are not specifically addressed.

Given the nature of his assignment, Levine's conclusions regarding the topic of stress and performance are important and interesting; therefore I quote his observations at length:

The literature concerning stress is extensive and complex, extending through fields as varied as clinical applied psychology, anthropology, sociology, psychosomatic medicine, industrial relations, and epidemiology. Not included in this list are, of course, the extensive studies dealing with the biochemical and physiological of the responses to stress. These responses have

been involved in mechanisms as basic as immunological function, metabolic function, and fundamental psychological processes, such as memory and learning. Since one of the primary problems in stress research is conceptual, and this problem takes many forms, *there is a great deal of confusion in the field* [italics added]. (p. 2).

My contention of independence among the three literatures, is supported by the following remarks by Levine:

Because stress researchers lack a common vocabulary, each writer must define his/her own terms, and the reader must scrutinize each article carefully in order to understand the writer's vocabulary. The lack of a uniform and consistent vocabulary is a substantial impediment to progress and adds materially to the confusion in the field. Although the term "stress" is used throughout the literature, it is apparent that this term has multiple meanings, depending upon the particular field in which the concept is being investigated. Within the context of this report, we shall attempt to use one set of operational definitions to define stress, and at least to be consistent with our own definitions of the primary psychological variables that induce many of the profound long-term effects commonly attributed to stress. Stress can be approached from a purely behavioral perspective, and it effects studies on primarily behavioral outcomes. However, stress has also been viewed predominantly as a physiological and psychosomatic process, and the outcomes are studies on either pathophysiological processes or basic biological processes. This report, however, will focus on an integration of these two perspectives and present a psychobiological view of stress. (p. 2).

The remarks by Levine offer a broad overview of considerable interest, underscored as they are by endorsements from prestigious sources. Therefore, several features should be noted before leaving them.

- Levine describes the field of stress research as suffering from "a great deal of confusion"; second, the field lacks "a common vocabulary"; third, the "lack of a consistent and uniform vocabulary is a substantial impediment to progress" (p. 2). These are very broad and discouraging observations. They make one wonder how Swets and Bjork could reach their unqualified conclusion that "the clear thrust of the evidence from various types of research on stress . . . is that an individual's uncertainty about impending events and sense of control over them are the main factors in perceived stress" (p. 89) if Levine's descriptions are correct.

- There is good reason to doubt that Lazarus or other researchers in the clinical/personality/social literature would agree that uncertainty and lack of control are the "main factors," although they would agree that these two stressors, among others, are important. Nor is this the conclusion that has been offered by Hockey, Hancock, and other numerous researchers in the ergonomics/human factors literature, although, they too, would surely acknowledge their importance. Indeed, there is an entire book devoted to the question of "control" (*Job Control and Worker Health*) edited by Sauter,

Hurrell, and Cooper (1989) that presents a collection of work that is empirically ambivalent with respect to the importance of "control" as a stressor.

- The material that Levine does review falls almost entirely within Literature III—the psychophysiology of stress. Literature I is ignored. Of the approximately 100 citations, there is only one to Lazarus (1974), none to Janis, none to Sarason or Mandler. The articles cited by Levine that might be considered to bridge the gap between Literature I and Literature III—an attempt for which he should be given credit—are, unfortunately, not substantial ones. Indeed, they approximate the anecdotal, and as Levine notes, the results can often be interpreted in different ways.

- The work on human factors (Literature II) is also ignored. There are no references to Hockey's extensive publications, nor Hamilton's, nor Hancock's; there are a few references to rarely cited experimental papers in Literature II. The nearest approximation cited by Levine is an early (1964) article by Stotland and Blumenthal on "The reduction of anxiety as a result of the expectation of making a choice". The work in judgment and decision making (Literature IV) is also wholly ignored, but it must be remembered that Literature IV contains essentially no research on the effects of stress, certainly none on the psychobiology of stress and decision making. So there was little for Levine to cite even if his aim was to link the two. Nevertheless, Levine's focus on the physiological literature illustrates the risk of ignoring other Literatures. For example, in discussing the role of control in stress management, he cites studies of aircraft controllers by Rose (Rose, Jenkins, Hurst, Herd, & Hall, 1982; Rose, Jenkins, Hurst, Kreger, Barrett, & Hall, 1982; Rose, Jenkins, Hurst, Livingston, & Hall, 1982) in which "there appeared to be little in the way of increased stress physiology under working conditions which were presumed to be stressful" (Levine, 1990, p. 17). Levine then explains away these negative results by concluding "that as a consequence of their extensive work experience [average was 11 years] these individuals had developed adequate coping mechanisms . . . which enabled them to minimize the psychological consequences of their stressful occupations" (p. 18). But Levine's assumption about the independent variable, stress, was uncritically made. Smith's (1985) extensive survey—cited within Literature II—showed that the aircraft controllers' occupation is not stressful, a fact consistent with Rose's (1982) physiological findings.

- Surprisingly, Levine's review verges on the anachronistic. Of the 105 references, only 11 are dated subsequent to 1980. Of these post 1979 citations, three refer to Rose's 1982 articles, and six refer to Levine's own work prior to 1983. The most recent citation in the entire bibliography is one for 1985. In short, aside from Levine's self-citations, ninety-five per cent of the referenced articles were published prior to 1980, a fact which casts doubt on Swets and Bjork's reference to Levine's report as "an extensive review paper" (p. 89). Clearly, they should have referred to an "extensive review paper based on research prior to 1980." Even a cursory review of Literature III will reveal considerable work during the decade of the 80s, without which Levine's 1990 review is clearly inadequate. For example, Levine overlooked the impressive volume on *Energetics* edited by Hockey, Gaillard, and Coles (1986) that contains a wealth of material related to performance (at least 100 references to psychobiology and performance) since 1979.

In short, Levine's own descriptions of the field of stress research, together with the time-restricted scope of his review, makes the generalization "that an individual's uncertainty about impending events and sense of control over them are the main factors in perceived stress" (Swets & Bjork, 1990, p. 89) offered by him and supported by Swets and Bjork doubtful, if not untenable. The best source of work on the physiological aspects of stress and performance, if not judgment and decision making, is in the human factors/ergonomics literature. (For examples, see Hockey, 1983a, 1986.)

Chapter IV
Literature IV
(Human Judgment and Decision Making)

On August 3, 1988, the Defense Policy Panel of the Committee on Armed Services of the U.S. House of Representatives began a hearing which provides a crucible for our current understanding of the effects of stress on judgment and decision making. The hearing was called to consider "the administration [sic] proposal to pay compensation to the victims of Iran Air Flight 655 which was shot down [by the American cruiser Vincennes] over the Persian Gulf on July 3" (Hearing, p. 1). Subsequent to the initial inquiry regarding compensation, on October 6, 1988, the Chairman of the House Committee on Armed Services called a hearing "to examine the impact of human factors such as stress" on the crew's performance, which, the Chairman said "raised some interesting issues" (p. 189). Among the "interesting issues" identified by the chairman were two that are intrinsic to the principal question pursued here, namely: (a) "Does the performance during the shootdown [of Iran Air 655] identify aspects of human behavior that are poorly understood?" and (b) "What have researchers uncovered to date on man's ability to make rapid and even complex decisions in high-stress environments?" The chairman then observed that "to help explore these questions, we have a very distinguished panel of behavioral scientists gathered with the help of the American Psychological Association." In addition, the Chairman noted: "We have Dr. Steven Zornetzer from the office of Naval Research and Commander Paul X. Rinn, former commander of the USS. *Samuel B. Roberts*" (p. 189).

The four behavioral scientists were indeed "very distinguished," primarily for their work in the field of judgment and decision making, and therefore their statements to the panel provide an opportunity to learn what the context of Literature IV will contribute to understanding the effects of stress on judgment and decision making in general, and to discover "what researchers uncovered . . . on man's ability to make rapid and even complex decisions in high-stress environments" in particular. In addition, Steven Zornetzer, Director, Life Sciences Directorate at the Office of Naval Research (ONR), had direct access to the research reports made over the past decade by (some of) these scientists, as well as many others to the ONR regarding research on judgment and decision making. Thus, Dr. Zornetzer's testimony to the committee would be informed as a result of what ONR had learned during the (roughly) 10 years it had supported such research. Moreover, Commander Rinn would offer his conclusions regarding this topic. His conclusions would not be based on research, but on his direct experience with stress and judgment and decision making during combat in the Persian Gulf.

I consider each expert's testimony separately.

Psychologists' Testimony

First, it is noteworthy that two of the four experts (Nisbett and Pew) do not cite research that relates stress and judgment and decision making. Nisbett focuses on the fallibility of cognition in general, and Pew focuses on questions related to decision aids and other aspects of decision systems largely derived from Literature II.

Second, of the two experts who directly address the question put to them by the Chairman, Helmreich pointed out that "the whole area of stress is one that has been understudied" and observed that "We know little about stress in group situations" (Committee on Armed Services, 1989, p. 230). It is Slovic, however, who makes plain the absence of scientific knowledge about the topic, thus: "It is rather surprising to see how few studies have examined the effects of stress. . . . There are only a handful of laboratory studies that manipulate stress and observe the effects on complex judgment and decision making tasks. Most of these have employed time pressure as the source of stress" (Committee on Armed Services, 1989, p. 196). And in his written testimony, Slovic (p. 200) reiterated the need for research on stress and judgment and decision making. Again, later in his written testimony he stated that it was "astounding to see how few studies have examined the effects of stress" (Committee on Armed Services, 1989, p. 209) and noted that a 1988 NAS Committee recommended to Congress that such research should be undertaken (Committee on Armed Services, 1989, p. 209).

Slovic alone indicated some appreciation of the existence of Literature I when he gave credit to work by Janis and Mann (1977), thus: "Perhaps the most detailed theoretical treatment of stress in decision making has been provided by Irving Janis and colleagues (e.g., Janis & Mann, 1977)" (Committee on Armed Services, 1989, p. 209). He made no further reference to Janis and Mann's work, however. He also gave passing recognition to Literature II when he pointed out the importance of the relation between "display features and . . . response structure."

Consistent with his frank statements about the "astounding" absence of research on the effects of stress on judgment and decision making, Slovic listed only six studies that have been done. He did claim, however, that "several consistent findings have emerged from these studies," thus: "Under time pressure, the decision maker adopts a simpler mode of information processing. Rather than evaluate alternative actions completely, weighing and making tradeoffs among all the relevant attributes of each option, attention is focused on the one or two most salient cues and these tend to determine the decision" (Committee on Armed Services, 1989, p. 210). Further, "negative information gains in importance under time pressure. If the situation involves risk, time pressure leads to more cautious, risk-avoiding behavior, with greater importance given to avoiding losses" (Committee on Armed Services, 1989, p. 210).

Slovic concluded his review of research by stating: "In sum, studies of decision making under stress have uncovered important and consistent patterns of degraded information processing." But his conclusion was followed by the qualification that "research is needed to determine whether other forms of stress have effects similar to those of time stress to determine whether different types of judgment and decision making are more or less susceptible to the effects of stress, and to determine ways to reduce those deleterious effects" (Committee on Armed Services, 1989, p. 211). As we shall see below, his qualification is important.

Slovic's conclusions regarding the effects of (time) stress on judgment and decision making provided the only documented empirical research that

was offered by the four experts. The knowledge produced was hardly definitive, and its base gave credence to Slovic's earlier remark that only a "handful of studies" was available. Indeed, he might have noted that the best indication of the status of stress research in the J/DM literature is that stress has never been indexed in *any* of the *Annual Review* articles on judgment and decision making that have appeared.

Taken as a whole, the testimony by the four experts in judgment and decision making gave a definite answer to the first question asked by the committee chairman ("Does the performance during the shootdown [of Iran 655] identify aspects of human behavior that are poorly understood?"); the answer given by the experts was obviously "yes; judgment and decision making under stress." The answer to the second question ("What have researchers uncovered to date on man's ability to make rapid and even complex decision in high-stress environments?") was not clear. But with respect to confidence in generalizations supported by empirical research, the answer must be: "almost nothing."

Nevertheless, generalizations about complex decision making "in high-stress environments" are made by those whose administrative positions (and scientific background) require that they be informed about these topics. For example, based on what he had learned from ONR-supported research, Zornetzer, the Director of the Life Sciences Directorate at ONR, offered a positive, unequivocal answer to the second question: "One of the things that happens under stress, for example, is the focus of attention shrinks. You tend to ignore more and more. You tend to try to focus in on just the critical issues, just the critical elements you need to get by to the next moment" (Committee on Armed Services, 1989, p. 391). Slovic's remarks (p. 210) emphasized much the same conclusion, albeit in more technical terms.

Commander Rinn's Testimony

Before commenting on the remarks by the four experts in JDM and Zornetzer, it will be important and useful to turn to the testimony offered by Commander Rinn. His remarks were eloquent, and they were absolutely central to the topic of judgment and decision making under stress. Most important, they were in direct contradiction to the experts' contention that severe stress degrades the quality of judgment and decision making. It is obvious from the printed record of the hearings that his testimony was of great interest to the committee. Several points stand out in Commander Rinn's testimony:

1. He was absolutely convinced that his *training* and the training given his crew members were excellent; it prepared him and them for the very stressful conditions they encountered when they found themselves battling a dangerous fire while their ship was taking on water after striking a mine in the Gulf. For example, "As a result of the training we received. . . . officers and crew of that ship were convinced that we could fight the ship successfully against all threats and we could save our ship if we had to" (Committee on Armed Services, 1989, p. 249).

2. He was convinced that training and preparation for combat (and crew selection procedures) were already of such high quality that further research on the effects of stress is apparently not necessary.

3. He found no reason to believe that his judgment and decision making was *impaired* by the severe stress he experienced in attempting to keep his ship afloat.

As it turned out, the Commander was right: "On the night of the 14th of April, when we received one of the largest explosions I have ever seen . . . , I can honestly tell you that the men of the ship reacted in some very impressive ways to the stress, to the danger, and to the catastrophic damage that we had" (Committee on Armed Services, 1989, p. 249). Evidence? They saved the ship.

We deviated from standard doctrine, but the important thing was that the members of my crew, when I told them to do that, and when I directed through the chain of command, carried out the orders and carried them out emphatically and executed the training that they had received, they didn't stammer, they didn't make mistakes, they didn't run the P250s the wrong way, but they did exactly what they had to do on the basis of the training they had gone through and because things had been made very clear to them how they had to function.

To talk about other things happening in the face of the death there was an incident in a space called AMR2, which was one of my last main engineering spaces left that was not on fire and not flooding. I went into the space after about 1 hour and 30 minutes and my repair party was working in the space, one that we had worked very hard with to teach shoring electrical maintenance and also dewatering of spaces. If you can imagine stepping into a space that if you lose it, your ship is going to sink in 5 minutes and confronting enlisted men who range from an E-7 Petty Officer on down to basic seaman, and there are 12 of them in the space, and you are looking at a bulkhead that has four holes in it the size of a football—correction, a basketball—and the seam in the midst of that bulkhead is split, with water pouring in and you are standing in water up to your knees and the fire pumps you need to keep the ship afloat are only a foot above the water level and so are the main diesels that you are running to keep power to the ship that you need to get the ship out of the minefield, dewater the space and fight the fire, and you know that you are not really sure you are going to make it another hour, and you look at these enlisted men who you have trained through all of this training we have talked about and who you have stressed, but not necessarily stress like this, and you say, "This is not a very good situation, but the situation is this: We must save the space or the ship is lost. If you don't save that bulkhead and you don't save the space, you are not going to get out of here."

They look at you, with great seriousness, with a small smile on their face and say, "Don't worry, Captain, we got this one in hand. In fact, this is nothing. You should see the next space."

You go with them and they show you that space and in fact, there is a hole larger than the others and they are working frantically to

close it. You quickly realize that these men have actually looked at the face of death and at the problem, and on the basis of the fact that they know how to do what they are supposed to do, they have confidence that they can succeed. It is only because of the training that they have and the confidence in the leadership. (Committee on Armed Services, 1989, p. 250-251)

In short, Commander Rinn strongly believes on the basis of hard experience, that his training program made it possible for him and for his crew members to exercise good judgment, and that their cognitive abilities were unimpaired by severe stress. This view, born of direct experience, directly contradicts the implications of the testimony by the four experts, and Zornetzer, that stress makes what is already a poor quality process worse (see especially Committee on Armed Services, 1989, pp. 190-193 [Nisbett] and pp. 199-213 [Slovic]). Thus, Commander Rinn's testimony indicates that any laboratory-based research conclusion must withstand the criticism of those who have experienced directly the situations for which the laboratory results are directed.

Such criticism was anticipated by the psychologists who created the research-oriented program for selecting spies for the newly-formed Office of Strategic Services at the beginning of World War II a half-century ago, thus

Since most of the critical situations which were confronting the majority of OSS men in the field were both novel and stressful, we made our testing situations novel and stressful. Thus it may be said that the situational tests used at OSS assessment stations were as lifelike as circumstances permitted, incorporating some of the major components of situations that would naturally arise in the course of operations in the field. In other words, we tried to design assessment situations that would be somewhat similar to the situations in the management of which candidates would be judged by their superior officers and associates in the theater. (The OSS Assessment Staff, 1948, p. 42)

Thus, almost a half century ago (1943) the psychologists on the OSS Assessment Staff were convinced of the necessity for the representative design of experiments.

Consensus Among the Experts

There were three conclusions on which the four experts agreed. (There were no disagreements among them.)

Absence of research. Two of the four experts from the field of judgment and decision making emphasize the absence of research on the effects of stress on judgment and decision making, and two of the four implicitly do so. The NRC Committee also noted the absence of research and recommended funding for such research.

Fallibility of human judgment increased by stress. All four emphasized the fallibility of human judgment, and despite the absence of substantial empirical evidence, all four indicate, more or less directly, that stress will have a "deleterious" effect on this already untrustworthy process.

Stress narrows the focus of attention. Only Slovic and Zornetzer were specific about the effects of stress; both indicated that the "focus of attention shrinks." Slovic was explicit about the negative consequences of the narrowing of focus, whereas Zornetzer implied that the consequences would be negative.

Comment

1. *Limited research.* Zornetzer's remarks notwithstanding, the testimony of the four experts is in agreement with the view put forward here—and documented in Chapter II—that Literature IV contains, as Slovic put it, "only a handful of studies." Zornetzer's documentation of the research supported by ONR did not list a single study of the effects of stress on judgment and decision making (Committee on Armed Services, 1989, pp. 260-271). How confident could he be that "attention shrinks" under stress? The answer must be "not very"—unless we are very specific about conditions, and state exactly what we mean by "attention," and are prepared to generalize from a very few studies. When Slovic offered this generalization he was careful to note that the studies he cited included only time pressure (one among a long list of stressors he accurately cited). But even with respect to time pressure, there are contradictory results. For example, Rothstein (1986) found that "cognitive control (consistency of execution of a judgment policy) deteriorated under time pressure while cognitive matching (of cue weights with the ecological validity of cues) remained unchanged" (p. 83). In other words, the attention span did not "shrink," consistency did. Payne, Bettman, & Johnson (1988) also found that "people appear highly adaptive in responding to changes in the structure of the available alternatives and to the presence of time pressure. In general, actual behavior corresponded to the general patterns of efficient processing" (p. 534). In view of these circumstances, we can hardly be confident in any generalization about the effects of time pressure.

2. *Stress degrades an already fallible process.* As long ago as 1976 Poulton had challenged the conventional view that stress (induced by stressors other than time pressure) always degraded performance, by stating: "There are well known rules that heat, noise, and vibration degrade performance. Yet a number of experiments show that all three stresses can reliably *improve* [italics added] performance, especially in tasks requiring speed or vigilance. . . . Experiments reporting improvements in performance need to be remembered as well as the experiments reporting degradations" (1976a, p. 1193).

Research carried out by the present author and his colleagues under ARI Contract MDA903-86-C-0142 (Lusk, Mross, & Hammond, 1989) offers an example. We found clearly better accuracy of forecasts by aviation weather forecasters under high stress (high weather activity, time pressure) conditions than low stress. When asked to explain this result, the forecasters indicated that the high weather activity (signifying danger to aircraft) served to help them "focus in on just the critical issues," as Zornetzer put it.

The possibility that stress might not degrade performance and may even enhance it was pointed out by Helmreich (Committee on Armed

Services, 1989, p. 239). And there are many references to this outcome in Literature II as well, many of which point out the weaknesses in an appeal to the Yerkes-Dodson "law" (e.g., Hockey, 1986a).

3. "Stress narrows the focus of attention"; a flaw? The generalization that one's "focus of attention shrinks" and that one "tends to ignore more and more" is not secure. First, however, suppose this generalization were true: Does it provide new information about human behavior? Hardly. In 1777, Dr. Johnson put it this way: "When a man knows he is to be hanged in a fortnight, it concentrates his mind wonderfully." It does not come as a surprise to learn that the time pressure "concentrates [the] mind wonderfully"—at least on some occasions; the problem is to know when—aside from hanging.

Nevertheless, even though probably not generally true, and not new, we should ask: Is it in fact "deleterious" for the "focus of attention to shrink"? Is it altogether a bad thing if under stress we "ignore more and more" and "focus in on just the critical issues"? Isn't that exactly what Commander Rinn did when he consciously decided to deviate from "all of the damage control doctrines that we were required to observe in the United States Navy," "forget fighting the fire," and "continue to dewater the ship" (Committee on Armed Services, 1989, p. 250)? Wasn't he "focus[ing] in on just the critical issues"? Evidently it was exactly right for him to "forget fighting the fire" and concentrate on continuing to "dewater the ship," that is, "focus in on just the critical issues." As a result, he saved the ship. The same argument could be put forward for the aviation weather forecasters who improved their performance under stressful (high activity) days. As noted above, the forecasters attributed the improvement in performance to increased concentration due to increased danger to aircraft.

Whether "focusing" is harmful or helpful raised the question of "optimal" behavior, another topic that is hardly new. For example, Wickens (1987) states:

The phenomenon of perceptual narrowing with arousal increase has received only few experimental demonstrations in more applied multicue situations such as the aircraft cockpit, or the industrial monitoring station, although anecdotal reports indicate that it is present there as well (Sheridan, 1981). One more applied context is the stress imposed by underwater diving. In a simulation of this hazardous environment, Weltman, Smith, and Egstrom (1971) found that a diver's ability to detect peripheral stimuli was impaired. It is important to note, however, that the phenomenon represents a mixture of optimal and non-optimal behavior. Arousal produces a non-optimal response by limiting the breadth of attention. *But subject to this limit, the human appears to respond optimally by focusing the restricted searchlight of attention on those environmental sources that are judged to be most important [italics added].* (p. 64).

Wickens's recent research (Wickens, Stokes, Barnett, & Hyman, 1988) on pilot judgment under stress is perhaps the most sophisticated; the scope is broader than in most studies, and the work does take into account some contemporary research in judgment and decision making, as well as cognitive psychology in general. Wickens's approach may thus be the

forerunner of work in this field. His conclusions, although tentative, are important. For example,

In our experimental examination of the influence of stressors on pilot judgment, it was first important to demonstrate that the manipulations had indeed imposed a cost on decision making quality. The performance data . . . suggest that such an effect was in fact obtained. This result in itself is significant and important, for in spite of the many anecdotal reports of stress effects on pilot judgment, only one experiment located in the literature has actually manipulated stress and systematically induced a performance decrement on domain-specific decision behavior (Bronner, 1982). Even in Bronner's study, the problems were far more structured and homogeneous, dealing with utility-based business marketing decisions, than were the heterogeneous set of problems used in the current study. Hence, the demonstration in the current study that stress manipulations can degrade performance, while in hindsight perhaps not surprising, remains an important initial finding. (Wickens et al., 1988, p. 29)

One finding that is particularly relevant to the question of degradation of performance was that "our manipulations did not simply produce equivalent effects across all decision problems, as revealed by the *absence* of stress effects when the spatial load was small. . . . Correspondingly, a conclusion that *any* manipulation of problem demand might enhance the degrading influence of stress is countered by the analysis of problems categorized by . . . [variations in] knowledge demand" (Wickens et al., 1988, p. 31).

Wickens's (1987; Wickens et al., 1988) conclusions thus encompass all of my conclusions noted above: (a) Only a few studies support the perceptual narrowing phenomenon; (b) the finding that "stress manipulations can [but not *do*] degrade performance" is not surprising, that is, not new; (c) the statement, "our manipulations did not simply produce equivalent effects across all decision problems, as revealed by the absence of stress when spatial load was small" indicates lack of generalization within the same domain, together with (d) the observation that "any manipulation might enhance the degrading influence of stress . . . was countered" by further studies.

As studies of the sort conducted by Wickens become more frequent, our understanding of the effects of stress on judgment and decision making will become more differentiated, more dependent upon theory, and results more contingent upon task circumstances—until a theory of task circumstances allows prediction of cognitive activity—an argument put forward by the ecological psychologists Brunswik and Gibson decades ago.

The reader should be reminded that the material upon which the above critique is based is *testimony* given to lay persons, not published research articles. It is therefore to be expected that there would be less documentation of conclusions in testimony than in a journal publication. And indeed, the annotated bibliography to follow in this report indicates that the experts testifying in 1989 would have been able to base their testimony on more articles than they presented, had they the time and facilities to carry out the bibliographic work, which, we presume, they did

not. Nevertheless, as the attached bibliography shows, there are few empirical articles in Literature IV that *directly* link stress to judgment and decision processes as they are studied in contemporary (1960-1990) work. The conclusions offered would not have been markedly different, nor would the empirical support be markedly strengthened had the experts been preparing a journal article. Slovic's statement that "there are only a handful of laboratory studies that manipulate stress" (Committee on Armed Service, 1989, p. 196) would remain essentially unchanged.

Conclusions

I began by asserting that (a) there are four literatures relevant to the question of the putative effects of stress on judgment and decision making, (b) three of the literatures contain material on stress but not on judgment and decision making as currently (1960-1990) conceived, (c) with one exception, the three literatures are largely independent of one another, and (d) the fourth literature, containing material on current (1960-1990) work on judgment and decision making, is almost entirely devoid of work on the effects of stress. I then provided a brief overview of the current situation in each of the four literatures by examining recent expositions on this topic by leaders in each of the four literatures. My conclusion is that the above assertions, although not correct in detail, are correct in general; the largest exception being that I was wrong in asserting the independence of the ergonomics human factors literature and the psychophysiology literature. (The best refutation of my assertion can be found in Hockey, Gaillard, and Coles, 1986.) Nevertheless, I stand by my argument that *no* generalization about the effects of stress on the processes of judgment and decision making can be supported by the literatures. All generalizations are situation bound, and the limits on generalizations from the research situations employed are as yet unknown.

Of course, that is a very important conclusion, and, of course, it may be wrong. Therefore, in Part II, I provide an annotated bibliography upon which my conclusion is based. The reader must judge for him/her self whether the bibliography is adequate and whether the material in it justifies my conclusion. If the reader does find the conclusion to be correct, s/he will want to know how this situation can be rectified. I provide my answer to the question in Part III in which I put forward a general model that will provide a means for integrating the four literatures.

PART II LITERATURE REVIEW

Progress in the field of stress research is marked by a clear division of three literatures (indicated also in a history provided by Appley and Turnbull, 1986).. One literature is oriented toward the clinical/personality/social psychology of the effects of stress on cognition and other processes, exemplified by the persistent work of Lazarus, Janis, and others. A second literature is oriented toward ergonomics, or human factors psychology, exemplified by the work of Hockey, Hammilton and Hancock among others. As might be expected, the former is dominated by theory, research and generalizations that are broader in scope, less precise in terminology and measurement, less experimental and more psychological-test related than the latter. Both literatures are more voluminous, but the former has far more popular appeal than the latter. Also, as might be expected, the two literatures exist in almost perfect isolation; cross-citations are almost nonexistent. The second, human factors literature, does have some links with the third, psychophysiological literature, but none to the fourth, the judgment and decision making literature.

Most important for the purpose of this monograph is the fact that these three literatures do not include any significant amount of material from modern research (1960-1990) on judgment and decision making. There are a few scattered, brief references to work by Kahneman and Tversky, but the work of Norman Anderson, Hal Arkes, Berndt Brehmer, Robyn Dawes, Michael Doherty, Ward Edwards, Hillel Einhorn, Baruch Fischhoff, Reid Hastie, Robin Hogarth, John Payne, Paul Slovic, and Thomas Wallsten, to mention only a few, is essentially ignored. Either the thousands of theoretical and empirical research articles in the contemporary literature of judgment and decision making have not been read, or have been read and judged to be irrelevant by the researchers in the three fields mentioned.

Only recently have human factors psychologists begun to notice the J/DM literature. As noted above, a recent book by Hancock entitled *Human Factors Psychology* (1987) includes a chapter by a judgment and decision researcher (D. Kleinmuntz) that describes this literature, and a chapter on short-term memory by Klapp that cites recent work in cognitive psychology. But the other chapters in this book generally ignore this work. Even Hancock's chapter (with Chignell) that includes a section on "Stress and Adaptive Functioning," scarcely alludes to modern judgment and decision research, and makes only one passing reference to the clinical/personality/social literature.

It seems reasonable to suppose that our understanding of this complex topic would be enhanced if the four literatures were brought into contact with one another. Therefore, in Part I of this monograph I try to organize them in a manner that will prove useful to those who are producing Literature IV so that in the future when these researchers do investigate the effects of stress, they will be provided with knowledge of relevant work.

Chapter I Literature I

Theories

Janis, Lazarus, and Mandler are among the prominent theorists in the clinical/personality/social literature of stress and cognition. However useful their theoretical work may be for the purposes the authors intended, it does not provide a degree of formality sufficient for the type of research on judgment and decision making considered here. Also, as might be expected under these circumstances, the theories within this literature do not compete. Indeed, the isolation *between* Literatures I, II, and III is paralleled by isolation *within* Literature I; the theorists hardly acknowledge the existence of other theorists. For example, in the recent far-ranging article entitled "Theory-Based Stress Measurement," Lazarus (1990) does not cite Janis, Mandler, or *any* of the theorists mentioned below. The reverse is also generally true; they seldom cite him. In short, a primitive, idiosyncratic state of theorizing exists in Literature I; such theories apparently have considerable popular appeal but do not offer cumulative science.

Nevertheless, current theories of stress in Literature I—which generally encompass a much wider range of psychological functions than judgment and decision making—offer numerous ideas and hypotheses which can hardly be ignored by researchers in this field, and which almost certainly would be reinvented if they were ignored. Therefore I present brief descriptions of several theories that bear on the topic of stress and its cognitive consequences. Regrettably, they must simply be noted and briefly characterized; comparison is impossible because of their differences in form and content.

In order to avoid miscommunication, insofar as possible direct quotations from the author's text are presented and commented upon briefly.

Lazarus (1990)

The following quotations from Lazarus's article on "Theory-Based Stress Management" will indicate his present views, thus:

Psychological stress refers to a particular kind of relationship between person and environment (Lazarus, 1966; Lazarus & Folkman, 1984, 1987). The stress relationship is one in which demands tax or exceed the person's resources. The unit of analysis is an ongoing transaction or encounter which is *appraised* by the person as involving harm, the threat of harm, or a positive, optimistic, mobilized, and eager attitude about overcoming obstacles, which I have called *challenge*. Once a person has appraised a transaction as stressful, *coping* processes are brought into play to manage the troubled person-environment relationship, and these processes influence the person's subsequent appraisal and hence the kind and intensity of the stress reaction. This cognitive-relational view, which once had to overcome entrenched behavioristic resistance, is now all but dominant. There is no need, therefore, to recount in detail the concepts of appraisal and coping.

which have now become part of the routine vocabulary of researchers in the field of stress.

Transaction implies that stress is neither in the environmental input nor in the person, but reflects the conjunction of a person with certain motives and beliefs (personal agendas, as it were) with an environment whose characteristics pose harm, threats, or challenges depending on these person characteristics.

Transaction also implies *process*. The stress relationship is not static but is constantly changing as a result of the continual interplay between the person and the environment. For example, in problem-focused coping, the actual terms of the relationship are changed, which in turn affects the appraisal. In emotion-focused coping, what is attended to may be changed, or its meaning is changed as when the person denies or distances from the threat, which in turn also affects the appraisal. In effect, stress is a multivariate process involving inputs, outputs, and the mediating activities of appraisal and coping; there is constant feedback from ongoing events, based on changes in the person-environment relationship, how it is coped with and, therefore, appraised (see Folkman & Lazarus, in press).

This view has dramatic consequences and poses great difficulties for stress measurement. It abandons a simple input-output analysis and becomes a fluid systems analysis involving a host of variables that influence each other in time and across the changing contexts of adaptation. The best way for the reader to see this is to examine the system of interdependent variables and processes in Table 1, which is one version, and to ask the question of where and what stress is, in this kind of analysis, and how it might be measured.

Table 1. Illustrative System Variables for the Stress and Emotion Process

Causal Antecedent	→	Mediating Process	→	Immediate Effect	→	Long-Term Effect
Person Variables Values, Commitments, and Goals General Beliefs, Such as: Self-Esteem Mastery Sense of Control Interpersonal Trust Existential Beliefs		Encounter 1...2...3...n Within an encounter Time 1...2...3...n				
		Primary Appraisal (Stakes)		Affect		Psychological Well-Being
		Secondary Appraisal (Coping Options)		Physiological Changes		Somatic Health/Illness
Environmental Variables Demands Resources (e.g., Social Support Network) Constraints Temporal Aspects		Coping (Including Use of Social Support) Problem-Focused Forms Emotion-Focused Forms		Quality of Encounter Outcome		Social Functioning

Notes: Although not shown here, the model is recursive. Also, note parallelsism between short-term and long-term effects.

(Lazarus, 1990, pp. 3-4)

These remarks should be sufficient to enable the reader to grasp the conceptual level of Lazarus's theory of the effects of stress on behavior. They will also serve to enable the reader to see the distance between theorizing of this type and that developed in the field of judgment and decision making.

Mann and Janis (1982)

In this article, Mann and Janis present a "conflict theory" of decision making. Their model "is primarily concerned with identifying factors that determine the major modes of resolving conflicts. It describes how the psychological stress of decisional conflict affects the ways in which people go about making their choices" (p. 341). Mann and Janis "postulate that there are five basic patterns of coping with challenges that are capable of generating stress by posing agonizingly difficult choices" (p. 344).

The first coping pattern is "unconflicted adherence [in which] the decision maker complacently decides to continue whatever he or she has been doing, which may involve discounting information about risk of losses" (p. 344). The second pattern is "unconflicted change [in which] the decision maker uncritically adopts whichever new course of action is most salient or most strongly recommended" (p. 344). The third coping pattern is "defensive avoidance [whereby] the decision maker escapes the conflict by procrastinating, shifting responsibility to someone else, or constructing wishful rationalizations to bolster the least objectionable alternative,

remaining selectively inattentive to corrective information" (p. 344). The fourth pattern is "hypervigilance [in which] the decision maker searches frantically for a way out of the dilemma and impulsively seizes upon a hastily contrived solution that seems to promise immediate relief. . . . In its most extreme form, hypervigilance is known as 'panic'" (p. 344). The fifth coping pattern is "vigilance [whereby] the decision maker searches painstakingly for relevant information, assimilates information in an unbiased manner, and appraises alternatives carefully before making a choice" (p. 345). Mann and Janis hypothesize that, in general, the first four coping patterns tend to be maladaptive, whereas the fifth pattern usually meets "the main criteria for high-quality decision making" (p. 345). Mann and Janis also describe various related aspects of conflict theory.

Mann and Janis' "conflict theory" is not cast in a formal theoretical framework, however. The authors' claim that it "offers a general theory of decision making, not a theory of choice behavior. It is concerned with how human beings arrive at the key consequential choices of living and working, but not with predicting the actual choices they make" (p. 342). Janis, Defares, and Grossman (1983) discuss the hypervigilance coping pattern in further detail.

Although this general theory commands attention because of its clarity of expression and its appeal to our normal experience, its utility for judgment and decision researchers is limited and apparently intentionally so (see above remarks regarding "choice behavior"). Moreover, there is no direct appeal in this or later work to the contemporary literature of judgment and decision making.

Mandler (1982)

Although Mandler would perhaps better be described as an experimental psychologist than as a clinical/personality/social psychologist I include his approach in Literature I because of its broad intent. Mandler offers a theory of stress that labelled "interruption theory." "The basic premise of interruption theory is that automatic activity results whenever some organized action or thought process is interrupted. . . . That is, any event, external or internal to the individual, that prevents completion of some action, thought sequences, plan, or processing structure is considered to be interrupting. . . . It is important to note that interruption should not be imbued with negative characteristics; this process simply and neutrally involves the disconfirmation of an expectancy or the noncompletion of some initiated action. Interruption is not synonymous with frustration or other related terms. Interruption may be interpreted emotionally in any number of ways, ranging from most joyful to most noxious" (p. 92).

Mandler relates interruption theory to other theoretical conceptions of stress as well as to various aspects of cognition, such as memory, consciousness, and problem solving. He also discusses the problems that extensive previous use of the term "arousal" has caused and suggests a more precisely defined alternative.

Despite Mandler's careful development of "interruption theory" it has had little or no impact on the field of judgment and decision theory, nor is it

likely to unless it is brought to bear on contemporary approaches in that field.

Coyne and Lazarus (1980)

Coyne and Lazarus describe a "transactional" model of stress (referred to by Lazarus, 1990, in the quotation above). This model "is explicitly cognitive-phenomenological, emphasizing how the person appraises what is being experienced and uses this information in coping to shape the course of events. . . . The effects of the coping are in turn appraised and reacted to as part of the continuous flow of psychological, social, and physiological processes and events. Stressful commerce with the environment thus involves extensive psychological mediation and reciprocal feedback loops, [which]. . . . therefore requires that any comprehensive model of it be developed within a transactional, process-oriented perspective" (p. 145). In addition to describing their model in some detail, Coyne and Lazarus advocate naturalistic studies of stress, at the same time urging researchers to remain aware of laboratory studies. Coyne and Lazarus claim that the transactional model is a "radical redirection" from most of the current conceptions of stress.

The theories offered by Coyne and Lazarus, Janis and Mann, and Mandler and their co-workers are complex, and certainly relevant to the present topic. They remain very general and complex, however, which makes it difficult to generate specific predictions for specific circumstances. Much is dependent upon the subject's definition ("appraisal") of circumstances, and much is dependent upon the theorists' method of appraisal of a given subject's state at a specific time.

Levi and Tetlock (1980)

These authors are general with respect to process but specific with respect to content. They start with the premise that "previous studies have found that the cognitive performance of government decision-makers declines in crises that result in war. This decline has been attributed to crisis-produced stress which leads to simplification of information processing. The present study tested the disruptive stress hypothesis in the context of Japan's decision for war in 1941. Two content analysis techniques . . . were used to analyze the translated records of statements by key Japanese policy-makers. Comparisons between statements made in the early and late periods of the 1941 crisis yielded only weak evidence of cognitive simplification. Interestingly, however, the social context in which statements were made significantly affected the complexity of cognitive performance: Statements made in Liaison conferences (in which policies were formulated) were significantly less complex than statements made in Imperial conferences (in which policies were presented to the Emperor for approval). Theoretical and methodological implications of the results were discussed" (p. 195).

This study, although retrospective, is unique in that it explores the effects of stress on the political decision making by Japanese officials as they consider steps toward war. Thus, the authors chose an approach that favors the complexity of decision making outside laboratory conditions over the rigor afforded by them. Although the theorizing is focused on cognition, the

context is more nearly that of political science than psychology, and there is little here that will influence theories of the effect of stress on decision making.

Brecke (1982)

Brecke (1982), a former fighter pilot, presents a theoretical model that "unites the variables of cognitive complexity, time availability, uncertainty, and stress into one coherent model. The model is used to examine current aircrew training and to develop new training strategies for improving judgment performance" (p. 951). The model assumes that (a) "judgment task difficulty can be seen as the resultant vector of cognitive complexity, uncertainty, and the inverse of time availability" and (b) "stress will affect judgment performance in a non-linear fashion: positively up to an individual maximum and negatively beyond that. The stress in a situation requiring judgment can be thought of as consisting of three components: the null-level stress, stress resulting from the difficulty of the judgment task itself, and stress resulting from the interaction of the flight problem and background problem" (p. 954). Brecke describes the lack of training aircrews are given in making judgments in stressful situations. The need is particularly acute in the armed forces because of the extreme combination of variables such as cognitive complexity, uncertainty, time pressure, and stress. Brecke also describes a way to train individuals for difficult judgment situations.

Although Brecke's (1982) article offers a number of hypotheses about decision making under stress, he acknowledges that his suggestions for training people to make decisions under stress have "not [been] tested by either experiment or experience" (p. 957). Thus Brecke's ideas are interesting mainly because they are derived from his military experience. (Note remarks by Rinn above.)

Reviews

I provide only brief comments on the following reviews because the material covered is generally much broader than the present topic and because it overlaps with that included in the theoretical articles cited above. The articles are presented in chronological order inasmuch as they purport to review prior research.

Coyne and Lazarus (1980) review over 40 articles, but few are cognitively oriented. Mandler (1982) reviews over 40 theoretical and empirical articles on stress and thought processes, but few refer directly to judgment and decision making. Janis et al. (1983) review over 40 articles related to stress and decision making, few of which are cognitive in nature.

Saegert and Winkel (1990) in their review of "Environmental Psychology" note a more sophisticated and modern approach taken by Evans and colleagues, thus:

Evans & Cohen (1987) go beyond the frequently used classification of stressors into cataclysmic events, stressful life events, daily hassles,

and ambient stressors (Baum et al 1982; Campbell 1983; Lazarus & Cohen 1977) to outline eight dimensions along which environmental stressors vary: perceptual salience; type of adjustment required; value or valence of the event; degrees of controllability; predictability; necessity and importance; duration; and periodicity. They note that the physical nature of environmental stressors has been neglected in favor of psychological and sociological investigations of personal, organizational, and societal factors that influence stress and coping. (p. 448)

Chapter II Literature II

Theories

Conceptual work relating stress and cognition within Literature II is perhaps better characterized in terms of "approaches" rather than theories, with the exception of recent work by Hancock (Hancock & Chignell, 1987; Hancock & Warm, 1989), whose work we consider first.

Hancock and Chignell (1987)

In his chapter with Chignell, Hancock offers some observations before developing a theory of "Adaptive Control in Human-Machine Systems," for example, "it is the interaction between the factors of system complexity and operational magnitude that is driving contemporary technology beyond the unaided control capacity of the human operator" (Hancock & Chignell, 1987, p. 306); "contemporary systems have begun to emphasize knowledge-based operations where, in addition to consultative interaction with the machine, the human [being] is employed for capabilities such as pattern-recognition and inferential reasoning" (p. 307). Further, the goal of the operational unit "cannot be achieved by considering only *static* characteristics of the interface, but requires instead a *dynamic* and therefore adaptive interdependence" (p. 307), which is followed by: "It is our contention that adaptation is a costly process and is becoming an intolerable burden upon the loaded operator" (p. 308). These pressures lead Hancock and Chignell to develop their approach to stress, thus:

We offer a new view of stress, which is consistent with some elements of the foregoing arguments. However, our proposal contains a number of unique components which differentiate it from those previously discussed. This position has been generated (Hancock & Chignell, 1985) and elaborated (Hancock, 1986a; Hancock & Rosenberg, 1987) in a number of recent reports. Our purpose at this juncture is to provide sufficient information to allow the reader to follow our subsequent argument for mental workload as a form of cognitive stress response, and further to follow how such information provides a vital signal for input to an adaptive human-machine interface.

In our approach, a trinity of stress is represented in three descriptive loci. The first of these is an *input* locus composed of the deterministic physical characteristics, or *signature*, of the dynamic environmental display. The second locus is that of *adaptation* undertaken by the responsive individual to compensate for the perturbations introduced by the input stress. The final locus is an *output* value that represents the efficiency of performance upon an on-going, goal-directed task. As adaptation may be one of these latter goals, and as a task may be regarded as an input stress, it is clear that these three loci may overlap. (p. 312)

Hancock and Warm (1989)

The Hancock and Warm (1989) contribution is included here because it is the most recent comprehensive review and theoretical treatment. The

authors examine past work on the "effects of stress on sustained attention" and then go on to present "a dynamic model . . . that addresses the effects of stress on vigilance and, potentially, a wide variety of attention-demanding performance tasks" (p. 519). Their conclusions regarding the current 1989 state of theoretical work within Literature II are arresting: "There has been a collective failure of theories that seek to explain vigilance performance. . . . This failure is also true for theories of stress in general, which with few exceptions have exhibited similar stagnation" (p. 524). They further note that "the only theoretical construct that spans the two areas [vigilance and stress in general] is the concept of behavioral arousal" (p. 524). But Hancock and Warm then quote Koelega, Brinkman, and Bergman (1986), thus: "But arousal theory can explain any results, post hoc, and lacks predictive power. The position on the inverted-U curve can only be specified after the experiment, so arousal theory, in its present form, is not amenable to rigorous experimental testing" (p. 525). (See also Hockey, 1986, pp. 44-37—44-38 for a detailed critique and rejection of arousal theory.)

The general disappointment with theoretical progress in Literature II expressed by Hancock and Warm (1989) deserves to be taken seriously. It is based on a broad, expert understanding of Literature II, particularly as it relates to attention, which is the main cognitive area of interest in this literature. Their disappointment parallels that generally expressed in Literature I (see above quotations from Lazarus's 1990 review article in which, for example, he asserts that "stress measurement has almost never been truly theory driven"). Although disappointment in theoretical development is obvious, pessimism is not. And, indeed, were the participants in these two literatures willing to read (not merely note) the others' literature they might well find a certain convergence that would give rise to encouragement. For apparently both sets of theorists now believe that the concept of stress is too broad and must be far more differentiated than it is at present not only with respect to categories of sources—as we shall indicate below—but also in terms of behavior.

Hamilton (1982)

Hamilton's approach brings us closer to experimentally-oriented research on cognition. He favors making a "distinction among types of stress, particularly between stress as an effect and stress as an agent" (p. 105), and he argues "in support of an information processing concept of stress as an *agent* (italics added), where stress as an effect is seen as the consequence of the type and amount of information processing mediated by stressors, which contain and generate stressful information" (p. 105). Hamilton also distinguishes among physiological, cognitive, and psychogenic stressors. His main point concerns overloading short-term or working memory. Because all information used to guide behavior resides in working memory, it follows that stress can overload working memory's limited capacity. Thus, "by definition, cognitive stressors are those cognitive events, processes, or operations that exceed a subjective and individualized level of average processing capacity" (p. 109). This overload can result from a person's experience or inexperience with particular stimuli. Note, however, that "an event does not become a stressor until a cognitive processing system has identified it as such on the basis of existing long-term

Nevertheless, Hamilton's focus on information processing and memory is apt to make his theoretical work a source of interest for researchers in stress and judgment and decision making.

Hockey (1979)

Hockey is even more specific in his theory and research than Hamilton (above); thus, "The aims of this chapter are twofold; firstly, to attempt an integrated survey of research findings in the area of stress and performance and, secondly, to propose alternative methodological and theoretical approaches to the experimental study of stress effects in cognition. In reviewing the literature I have concentrated on two main areas of skilled performance, sustained attention and memory. This is primarily because most work has been done in these two fields and the findings are therefore more reliable. In addition, however, and this may be no accident, these two components may be considered as, in some ways, primary in the organization of skilled behavior" (pp. 141-142). Thus, although Hockey's 1979 work does not focus directly on judgment and decision making, it is certainly relevant; his views are informed and broadly-based.

In addition to pointing out the problems caused by referring to stress as both cause and effect, Hockey emphasizes the "widespread and largely uncritical acceptance of the Yerkes-Dodson law in human stress research. I do not want to object to its failure to describe the effects of stress adequately, but it blinds us to the recognition of more fundamental changes in functioning" (p. 144). More important questions are "What changes underlie the observations embodied in the Yerkes-Dodson law?" "Why are high levels of arousal bad for performance?" "What makes a task difficult?" In general these questions have been side-stepped in favour of circular reasoning and naïve operational definitions" (p. 144). (See also Hancock, ref.).

Hockey makes two recommendations: "Adopt an approach of examining the detailed effects of a single stressor across a range of tasks" (p. 170), develop "a realistic functional model of cognitive behaviour . . . with a closer link with the mainstream theory" (p. 170).

Hockey (1983b)

This is an important anthology despite its 1983 publication date. The authors of the 13 chapters are all experts in the various subdomain they review and comment upon. Of particular relevance are the chapters by Hockey and Hamilton on "The Cognitive Patterning of Stress States" and Hockey's chapter on "Current Issues and New Directions." Both chapters are informative in a negative sense, that is, they ignore judgment and decision making research.

In his summary chapter entitled "Current Issues and New Directions," Hockey (1983a) identifies four major themes of the research in Literature II, namely:

1. *"The use of arousal theory"*. "Unfortunately, it is now clear that arousal is a far more complex process than originally conceived. If we are to

continue to attempt to relate bodily and mental function . . . , it is clear that we need concepts more realistically suited to the task" (p. 364).

2. *"The recognition of the importance of task demands."* "Clearly, there is a great need for the development of a widely-accepted taxonomy for performance functions if this relationship between stress effects and task demands is to be made more generally useful and applicable to a wide range of work conditions" (p. 366).

3. *"The appreciation of individual differences."* "In the present state of our knowledge . . . we will need to examine these [individual] characteristics more closely than is possible using temperament or anxiety inventories. . . . A detailed study of individual behaviour under stress . . . may be a more fruitful line of research in the long run" (p. 367).

4. *"Interaction of field studies and laboratory experiments."* "The need to consider practical data forces us into developing theories which have a realistic range of application" (p. 368).

The new directions suggested by Hockey include: "broad-band methodology, coping strategies, long-term studies, and real-life behaviour" (p. 372).

Hockey's extensive 1986 review in the *Handbook of Perception and Human Performance* now emphasizes "general patterns of change" thus: "The approach taken here is to examine different states separately across a range of work situations to detect general patterns of change." Further, "it is emphasized throughout . . . that an assessment of stress effects requires information about the overall *pattern* of performance change across different kinds of function" (pp. 44-2). Although Hockey is a prolific researcher and writer, his contributions are more in the form of seeking integration and coherence among the work of others rather than in theoretical efforts.

Cox (1987)

Cox (1987) offers general ideas about stress and behavior in the workplace: "This article outlines the developing consensus on the nature of stress. It offers a definition of stress as a psychological state derived from the person's appraisal of their [sic] ability to cope with the demands which are made of them. The article then examines the concept of coping and explores its role in stress theory. . . . The article focuses on . . . [coping as problem solving] and in so doing it describes the nature of rational models of problem solving, considering their utility and application to stress management" (p. 5). Cox's theorizing is general in nature but does (not? check) bring the topic of stress into contact with contemporary theories of cognition.

Paterson and Neufeld (1987)

Patterson and Neufeld (1987) describe "the situational determinants of the primary appraisal of threat in a specific and systematic manner. Each potential determinant is broken down and the relevant empirical and theoretical literature is reviewed. Eight propositions about the workings of these factors are presented and discussed. Primary attention is given to the

factors of event severity, imminence, and probability of occurrence" (p. 404).

Poulton (1976a)

Poulton challenges existing beliefs about the effects of stress, thus: "There are well known rules that heat, noise, and vibration degrade performance. Yet a number of experiments show that all three stresses can reliably *improve* (italics added) performance, especially in tasks requiring speed or vigilance. Many of the results are not widely known, and those that are known may not be believed, whereas fallacious conclusions, which are consistent with the well-known rules, are sometimes accepted without ever checking up on them. In making recommendations for working conditions, the experiments reporting improvements in performance need to be remembered as well as the experiments reporting degradations. The ideal working environment for particular tasks is not necessarily free from all forms of stress. The questions used to obtain subjective assessment of stress do not usually provide categories to indicate that a stress can be beneficial. Subjective assessments do not necessarily mean what the investigator takes them to mean. They may be based upon a well-known rule and thus be consistent across observers. Yet they may indicate that performance has deteriorated when it, in fact, improved. Thus, subjective assessments are not an adequate substitute for measures of performance. Both subjective and objective measures are required in order to give a reasonably complete picture of the effects of stress" (p. 1193). Although Poulton made these observations in 1976, they remain cogent.

Baddeley (1972)

Baddeley was one of the first to examine the effects of dangerous environments on human performance. He reviews "evidence on human performance in dangerous environments" and suggests that "danger reduces efficiency, except in the case of experienced subjects. Perceptual narrowing is shown to be one source of decrement." He further suggests "that danger increases the subject's arousal level which influences performance by producing a narrowing of attention. The nature of the performance decrement and of adaptation to danger are discussed in this context" (p. 537). The hypothesis of perceptual narrowing is discussed by others (see "cognitive narrowing" below).

In 1983 Baddeley (with Idzikowski) updated this review. They offered

a general description of how an individual may respond in a dangerous situation. . . . The magnitude of any response will depend on a number of factors: (a) the individual's predisposition towards feeling anxious (trait-anxiety) and being aroused (trait-arousal); (b) the individual's assessment of the dangerousness of the situation and his ability to cope with it; and (c) previous exposure. The precise pattern of physiological and biochemical responses will vary from individual to individual unless the situation is perceived as being extreme. In an extreme situation increases in heart-rate, respiration-rate, skin conductance, and muscle tension can be expected, as well as increases in the secretion of catecholamines and various other hormones. Behaviourally, deterioration can be expected in manual dexterity, in

sensory-motor tasks such as tracking, and in performance of secondary tasks. It is probable that secondary task performance is reduced before central tasks are affected. (p. 140).

They also noted that their "findings are interpreted within the general arousal framework, which assumes an inverted U-shaped relation between arousal and performance" (p. 141) (but see Hockey, 1983b).

Friedland and Keinan (1982)

So far as can be ascertained, these are the only researchers who have investigated the efficacy of training for stressful conditions. (See Rinn above for a description of such training in the US Navy.) They empirically evaluated "graduated fidelity training" whereby the trainee is exposed to gradually increasing stressor intensities" and suggested that "it is potentially more effective than high fidelity training." However, they argue, "two conditions are necessary for the realization of this potential effectiveness. First, the trainee must be informed about the upper limit of the stressor intensity which he might encounter in the course of training. In the absence of such information, graduated fidelity training might become highly ineffective. Second, the trainee has to perceive high quality performance as being instrumental for the removal or attenuation of stressors" (p. 41).

This article is grounded in theory and is one of a small number of studies that compare ways of training people to perform a task under stress. It is uncertain to what extent the methods explored and the results obtained may be generalized to other tasks and stressors. It seems doubtful, however, that studies of this type would be convincing to military officers.

Rothstein (1986)

Rothstein (1986) chose the lens model (social judgment theory; see Brehmer & Joyce, 1988) conceptual framework as a specific theoretical context for an empirical study of the effect of stress. He concludes that "lens model analyses indicated that cognitive control deteriorated under time pressure while cognitive matching remained unchanged. This effect was limited to complex cue-criterion environments containing curvilinear forms. The results suggest that the time pressured individual tends to be erratic even while implementing correct policy" (p. 83).

Rothstein's (1986) work carries two implications: (a) it is a model for the experimental examination of the effects of stress on specific, quantified parameters of a theory of judgment; thus it benefits from both the rigor of the laboratory and the complexity of a general theory of judgment; and (b) it disconfirms the cognitive "narrowing" hypothesis by separating the parameter of cognitive control from that of narrowing. Thus, it shows that it is control that is diminished rather than the scope of attention. No other study makes this separation..

Schwartz and Howell (1985)

These authors also chose to examine the effects of stress on the specific theoretical parameters of Social Judgment Theory (see Brehmer &

Joyce, 1988). Variation of task parameters as well as cognitive parameters were included in the study design. They found that "display formation had a significant effect when time pressure was involved: subjects reached earlier and better terminal decisions under the graphic than the numerical format. . . . The difference reduced to nonsignificance under self-pacing . . . although significant improvements were obtained by use of a simple aiding device (calculation of worst-case probabilities). Results are generally consistent with Hammond's cognitive [continuum] theory" (p. 433).

This study is unique in employing theoretically specified conditions of information display conditions that predict different types of cognitive activity under stress and their subsequent effects on performance. Predictions were confirmed.

Reviews

For the most extensive recent review, see the *Handbook of Perception and Performance* (1986).

Baddeley (1972) reviews over 25 experimental and theoretical articles and concentrates primarily on studies of dangerous environments such as deep-sea diving. He also draws parallels from research on performance in other dangerous environments. Although the review is almost 20 years old it remains relevant to contemporary research. (See also Idzikowski & Baddeley, 1983).

Poulton (1976a) cites over 80 articles concerned with performance under stress. Studies involving three stressors—heat, noise, and vibration—are discussed. The author argues that generalizable conclusions are difficult to derive from studies of the effects of these stressors. Inconsistencies among studies are highlighted, although there is little discussion of potential theoretical explanations for these inconsistencies. Hockey's (1979) article reviews over 100 articles related to the effects of stress on cognition and behavior. Much of the material reviewed is now dated and restricted to stimulus-response studies, but Hockey makes important arguments concerning the Yerkes-Dodson law and suggestions for future research.

Hamilton (1982) reviews more than 40 articles related to information processing and stress.

Allnutt (1987) refers to approximately 50 articles related to human factors and accidents, with particular attention paid to military aviation accidents. The emphasis is on errors (human or otherwise) rather than stress, although several kinds of errors, contributing to accidents are distinguished, which the author terms "environment-aided errors." Allnutt's discussion of stress and human error includes (a) a criticism of the simplistic nature of research on the effects of stress despite the complexity of the phenomenon outside the laboratory, (b) the fact that "objective and subjective reactions to stress are often not well correlated" (p. 861); (c) various ways performance may break down under stress, such as narrowing of attention or "reversion" to well-learned behavior patterns.

Allnutt's review is cogent, if somewhat uneven in its coverage. It is perhaps flawed in that it occasionally offers generalizations without empirical support (see the discussion of "cognitive narrowing" below).

Cox (1987) reviews more than 40 primarily theoretical articles about stress in the workplace. The small number of empirical articles reviewed focus primarily on observational data.

Paterson & Neufeld (1987) refer to more than 90 empirical and theoretical articles, but few are directed toward cognitive processes.

Wickens and Flach's (1988) review of research contains only a brief reference to stress: "Human sampling [of information] is affected by high stress, which restricts the number of cues that are sampled. Those few cues which are sampled tend to be those that the pilot perceives to be the most important. Emphasis here is on 'perceives to be.' The pilot's perception of importance will not always reflect the true situation" (p. 118). The authors then cite the well-known example of the pilots who "became preoccupied with an unsafe landing-gear indication and failed to monitor the critical altimeter readings." They conclude that "in general, the sampling behavior of a well-trained operator will approach an optimal strategy . . . [but] limitations will arise due to limited memory and stress." The authors recommend that the design of information displays "should be such that the most important displays are also the most salient, particularly at times of high stress" in order to "ensure that the pilot's perception of importance agrees with the actual state of the world" (p. 118).

Although these conclusions carry significance for the study of stress and decision making, they are not supported in this chapter by references to empirical studies.

Melton (1982) reviews the research on air traffic controllers and air traffic control systems. It contains little substantive information on the effects of stress and decision making, although it does offer a point of view.

Wiener and Nagel's (1988) book contains 19 chapters, most of which contain material indirectly related to stress and decision making. Authors are mainly human factors researchers. (See especially Wickens & Flach above.)

The chapter by Hopkins (1988) reviews research results concerning the performance of air traffic controllers. The author's conclusions regarding the stressful nature of the aircraft controller's occupation are surprising (but see also Smith, 1985):

It was in the occupational health context that the issue of air traffic control as a source of stress on the controller was raised, a notion which more than a decade of extensive work has finally dispelled. . . . Contentions that air traffic control per se necessarily generates symptoms of stress in controllers, and that controllers as a group suffer chronically from stress problems, cannot be sustained. (pp. 654-655)

symptoms of stress in controllers, and that controllers as a group suffer chronically from stress problems, cannot be sustained. (pp. 654-655)

Hopkins then explains the "flaw in reasoning" that leads to mistaken conclusions about causal relations involving stress. He further declares that "the preoccupation with stress in air traffic control has in retrospect seemed particularly unfortunate, because it has led to the comparative neglect of a greater problem, namely boredom."

Chapter III
Literature III

Theories and Reviews

I do not present at this time either theories or reviews (with the exception of Levine, 1990) from the psychophysiological literature for two reasons: (a) It is my judgment that there are no psychophysiological theories available that purport to describe judgment and decision making processes (as currently conceived); (b) I am not prepared to describe or evaluate such theories or reviews if they were available (but see my comments on Levine, 1990, above).

Chapter IV Stressors

In this chapter various conditions used as stressors are described, irrespective of the literature in which they appear, although they are largely from Literature II. In each case (a) feasibility of use, (b) effectiveness as a stressor, and (c) reasons for choice of the stressor are indicated.

At least 14 different conditions have been employed to ascertain the effects of stress on cognitive processes. Some conditions are intended to be taken at face value as stressors; others rely on the subjects' performance or evaluation of his/her psychological—usually emotional—state.

Sleep Loss

Only Babkoff, Genser, Sing, Thorne, & Hegge (1985) and Babkoff, Thorne, Sing, Genser, Taube, and Hegge (1985) have investigated the effects of sleep deprivation on cognitive functions.

Feasibility of use. Sleep loss holds attractiveness for stress research; it is discomforting but essentially painless, leaves no scars, recovery is simple and quick, all subjects are familiar with it and know that it is harmless, and thus do not fear it. It carries direct implications for many important decision making situations. Its principal drawback is that inducing sleep loss requires considerable time and special circumstances.

Effectiveness as a stressor. There is little doubt that sleep loss has direct physiological results on cortical activity which is almost certainly related to cognitive activity that affects judgment and decision making.

Reasons for choice. Feasibility and effectiveness, and representativeness of significant political and military content.

Shock

Electric shock was used in 1974 by Bacon but apparently not used again until 1987 and then only as a threat by Keinan and his colleagues (Keinan, 1987; Keinan & Friedland, 1984; Keinan, Friedland & Ben-Porath, 1987).

Feasibility of use. The apparatus is simple, but the use of electric shock at a sufficient level to induce stress certainly means inducing pain. Therefore, it is unlikely to be used in university labs in the foreseeable future.

Effectiveness as a stressor. There is little doubt that electric shock and/or fear of it is stressful.

Reasons for choice. See preceding paragraph.

Dangerous Environments

Baddeley has been the foremost investigator (Baddeley, 1972; Idzikowski & Baddeley, 1983); see also Weltman, Smith, & Egstrom, 1971.

Feasibility of use. These circumstances cannot be employed in university laboratories unless (possibly) the subject is deceived. Effects of such environments can generally be ascertained only retrospectively.

Effectiveness as a stressor. There is little doubt about the effectiveness of this stressor; but anecdotes and retrospective studies offer wide varieties of interpretation.

Reasons for choice. High plausibility of effectiveness.

Time Pressure

This is possibly the stressor most widely used in studies close to judgment and decision making. See, for example, Ben Zur and Breznitz (1981); Payne, Johnson, Bettman, and Coupey (1989); Rothstein (1986); Schwartz and Howell (1985); and Zakay and Wooler (1984).

Feasibility of use. This is a simple, painless procedure with no side effects, with complete, rapid recovery, readily quantified and manipulated, and with direct implications for judgment and decision situations outside the laboratory, all of which makes it highly feasible to use, and which no doubt accounts for it being the most frequently used stressor in relation to judgment and decision making.

Effectiveness as a stressor. May vary, depending on other motivating factors; also difficult to separate effect of simple time limitations and stress due to time limitations.

Reasons for choice. Listed under feasibility paragraph above.

Unrepresentative Training

Friedland and Keinan (1982)

Feasibility of use. On the one occasion in which it has been used it appears to have been highly feasible; no pain or side effects are involved.

Effectiveness as a stressor. Because only one study has been conducted, little is known.

Reasons for choice. Situations that are novel and for which subjects are unprepared occur in many important judgment and decision making circumstances outside the laboratory (e.g., operations of ships, planes, power plants, process plants, etc.)

Fatigue

Christensen-Szalanski (1978); Krueger, Armstrong, and Cisco (1985)

Feasibility of use. Doubtful; inducing fatigue is time-consuming and may not be approved by human subjects committees.

Effectiveness as a stressor. Uncertain (but see Hockey, 1983b)

Reasons for choice. A commonly observed stressor in work environments, including the military.

Information Processing/Memory Load

Increasingly frequently recognized as a stressor (see especially Hamilton, 1982; Hockey, 1986b).

Feasibility of use. Highly feasible; researchers know how to do this, and human subjects committees will not disapprove because no pain, discomfort, or side effects will occur; memory load can be easily manipulated and quantified.

Effectiveness as a stressor. Uncertain, (see Hockey, 1986b, review).

Reasons for choice. See feasibility paragraph above; also will have direct implications for judgment and decision making in work environments.

Threat

A commonly observed stressor in military situations and elsewhere (see, e. g., Janis, 1983; Keinan, 1987; Keinan et al., 1987).

Feasibility of use. Low; human subjects committees are almost certain to object.

Effectiveness as a stressor. doubtful; much will depend on specific circumstances; can never be taken for granted that stress was in fact induced.

Reasons for choice. Resemblance to judgment and decision making situations outside the laboratory.

Political Crisis

See Levi and Tetlock, 1980.

Feasibility of use. Doubtful, can only be used retrospectively.

Effectiveness as a stressor. Uncertain.

Reasons for choice. Motivation to study judgment and decision making in circumstances in which it often occurs with great consequences.

Accident Avoidance

Malaterre, Ferrandez, Fleury, and Lechner (1988)

Feasibility of use. Moderate; while possible to simulate most aspects of the situation in a laboratory (as with drivers' training simulators) simulated situations are still missing certain kinetic and perceptual components. Field simulations (driving courses) are infeasible because of potential risk to the subjects.

Effectiveness as a stressor. Cannot ensure that a simulated situation is stressful. Only one study has been conducted and it did not contain a direct measure of stress. The actual stressor is short-lived; measurements would necessarily focus on post-trauma response.

Reasons for choice. Direct implications for judgment and decision making outside the laboratory.

Heat, Noise, Vibration

Hockey, 1970; 1983; Koelega and Brinkman, 1986; Koelega, Brinkman, and Bergman, 1986; Poulton, 1976a, 1976b; Wright, 1974.

Feasibility of use. Can produce discomfort or pain; have the benefits of being readily manipulated, quickly induced, easily quantified, and familiar to the subject. Human subjects committee unlikely to allow severe discomfort or pain.

Effectiveness as a stressor. High; have been studied for decades. Have been shown to have *both* incremental and detrimental effects on performance. Almost certain these stressors affect attention capacities in nontrivial, complex manner psychologically as well as physiologically.

Reasons for choice. Commonly encountered stressors, therefore externally valid. Obvious applications. High feasibility in laboratory setting.

Heat, Crowding, Confinement

Shanteau and Dino, 1983

Feasibility of use. High; convenient because it is commonly experienced, easily induced and manipulated, and readily quantified. Can potentially produce severe discomfort which would concern human subjects committee.

Effectiveness as a stressor. Can take considerable time to build-up stressful effects.

Reasons for choice. High feasibility; direct implications for judgment and decision making situations outside the laboratory

Exactingness

Extent to which the decision maker is penalized for failing to make appropriate decisions. Hogarth, Gibbs, McKenzie, and Marquis, 1990.

Feasibility of use. Easily implemented into a variety of task situations. Has additional benefits of being familiar to subject and readily induced and manipulated.

Effectiveness as a stressor. Dependent on how subject evaluates the situation; exactingness cannot be separated from the task situation in which

it is embedded, therefore it is hard to determine its relative effectiveness; for example, difficult to separate exactingness from punishment...

Reasons for choice. High external validity. Construct validity questionable due to the task and effectiveness interaction described above.

Stressful Work Situations

Smith, 1985

Feasibility of use. Unclear how these can be convincingly induced in the laboratory although field studies are highly feasible. If successfully induced, the stressor would be familiar to the subjects and readily manipulated.

Effectiveness as a stressor. Very effective stressor but quantifiable measures difficult to obtain.

Reasons for choice. High external validity and intuitive appeal.

Conclusions

Numerous stressors have been employed, both in the laboratory and field. Knowledge regarding their feasibility of use and effectiveness remains uneven and uncertain.

Chapter V
Behavioral Consequences (Dependent Variables)

Behavioral consequences are discussed below in terms of their (a) feasibility of measurement, (b) reasons for choice, and (c) conclusions drawn. The articles described are grouped according to psychological variables/functions studies. All three criteria are described insofar as possible in terms of the authors' views.

Before noting the contributions of individual articles under this heading, it should be noted that "attention" has been studied for several decades and there are thousands of publications on this topic. I have cited below only that small fraction of these studies that are more or less closely related to modern approaches to judgment and decision making. An excellent review of this material is provided by Wickens in Hancock's (1987) *Human Factors Psychology* (pp. 29-80).

Wickens's chapter is divided into "Metaphors of Attention," "Selective Attention," "Divided Attention," "Resources, Practice, and Difficulty," "Attention and Human Error," and "Changes in Attentional Function." Wickens's chapter includes over a hundred references; the reader should consult these in addition to the ones annotated here if his/her interests in judgment and decision making lie in its more peripheral aspects. Wickens concludes by stating:

The topic of human attention has been of interest to psychologists for over a century (Paulen, 1887). While human knowledge has clearly expanded since that time, the basic human constraints and limitations in processing information have remained unchanged. At the same time, the amount of information that humans are being asked to process, integrate, and understand as they interact with today's complex systems is increasing exponentially. Ironically, this fact remains true even as computer automation takes over many of the functions conventionally assigned to humans. This is because a human must now monitor and understand the automating computers and gracefully assume control if and when the automated system fails, as it often does (Rasmussen & Rouse, 1981). As system complexity grows, the number of things that must be monitored grows with it. The better understanding of human attention will not provide all of the answers necessary for coping with system complexity, but it will certainly offer a good start. (Wickens, 1987, p. 70)

Perception/Attention

Babkoff, Genser, Sing, Thorne, and Hegge, (1985)

Dependent Measure (DM). Lexical decision task

Feasibility of measurement. Readily used in the laboratory with a variety of stressors. Large supporting literature is available.

Reasons for choice. High feasibility and obvious external validity to situations involving perceptual discrimination.

Conclusion. Stress results in decrement in the ability to discriminate words from nonwords in both visual fields.

Babkoff, Mikulincer, Caspy, Carasso, and Sing (1989)

DM. Search task and pursuit rotor pattern tracing of veridical and mirrored images.

Feasibility of measurement. High.

Reasons for choice. Directly applies to multiple task situations involving time as a stressor.

Conclusion. Stress significantly reduced accuracy. This decrease was exacerbated by circadian rhythms. They also show that sleep loss produces a phase delay of circadian performance accuracy resulting in a 2-4 hr delay of peak performance. (See also Babkoff, Mikulincer, Caspy, & Kempinsky, 1988).

Babkoff, Thorne, Sing, Genser, Taube, and Hegge (1985)

DM. Visual search tasks, vigilance discrimination.

Feasibility of measurement. Lends itself well to laboratory study.

Reasons for choice. High feasibility.

Conclusion. Conclusions difficult to draw because measures were collapsed into test batteries and data from individual measures were not discussed.

Bacon (1974)

DM. Dual task: pursuit rotor and auditory signal detection.

Feasibility of measurement. Dual tasks can be stressful in and of themselves so care must be taken to ensure that one task does not overshadow the other.

Reasons for choice. High external validity to situations in which people must perform simultaneous multiple tasks.

Conclusion. Stress effects capacity limits and attentional control processes by narrowing the range of cues processed. This results from a systematic reduction of responses to low-priority aspects of the situation.

Friedland and Keinan (1982)

DM. Visual search task.

Feasibility of measurement. High, there is a large supporting literature. The method can be easily implemented within the lab and can be used in conjunction with most stressors.

Reasons for choice. High feasibility and reasonable external validity to other visual search tasks.

Conclusion. Task mastery and the ability to control stress (in this case threat) important for improving performance while under stress. Study showed that graduated unrepresentative training is superior to high unrepresentative training if (a) subject knows the upper limit of the stressor and (b) subject perceives their performance as instrumental in the removal or attenuation of the stressor.

Hockey (1970)

DM. Attentional selectivity within a pursuit tracking and multi-source monitoring task.

Feasibility of measurement. High; readily lends itself to laboratory study.

Reasons for choice. High external validity to visual dual task situations. Can be used with most stressors except stressors involving time.

Conclusion. The primary task (tracking) improved in noise condition. Centrally located signals were detected better than peripheral signals in the presence of greater noise. Authors conclude that there is greater attentional selectivity with arousal: perceptual narrowing.

Keinan (1982)

DM. Analogies test, scanning of alternatives.

Feasibility of measurement. Easily implemented within the laboratory with a wide range of tasks. Has supporting literature from studies done in nonstressful environments.

Reasons for choice. Externally valid for a variety of choice situations. Easily manipulated and implemented.

Conclusion. Subjects exhibited premature closure and nonsystematic scanning under stress.

Keinan & Friedland (1984)

DM. Visual search task.

Feasibility of measurement. Requires proficiency training otherwise the effect of stress with task performance thereby reducing reliability.

Reasons for choice. High external validity particularly to transfer of training.

Conclusion. Results are ambiguous; the authors suggest that while training under stress requires greater time, better transfer to novel situations is anticipated. However, the data here show that subjects trained in non-stress situations achieved higher performance levels in a shorter period of time and that this advantage was not overridden by the introduction of stress. (See also Keinan, Friedland, & Ben-Porath, 1987).

Weltman, Smith, and Egstrom (1971)

DM. Central visual acuity and peripheral light detection.

Feasibility of measurement. High, both task are easily implemented in the laboratory.

Reasons for choice. Direct applicability particularly to multi-task situations.

Conclusion. Subjects exhibited peripheral narrowing while under stress: while central visual acuity performance remained high, peripheral light detection performance declined. Stress also induced increased heart rates and longer response times.

Conclusion

Feasibility of measurement. The various measures related to perception readily lend themselves to laboratory study. In addition this area has an extensive supporting literature. Caution should be exercised when combining perceptual measures with manipulations of time because subjects strategies may change under time pressure. There is also the potential for floor and ceiling effects with increased stress and extensive training respectively.

Reasons for choice. High feasibility; perceptual measures lend themselves to use with a variety of stressors and are easily quantified both in terms of completion time and accuracy.

Conclusion. The papers discussed here suggest that stressful environments evoke longer task completion times and lower discriminability. One paper also showed that change in response bias was not a factor in the reduced performance levels. However, most of the studies focus on time decrements rather than performance decrements. Several studies discuss critically the Yerkes-Dodson law as a model of performance under stress.

Thinking

Babkoff, Thorne, Sing, Genser, Taube, and Hegge (1985)

DM. mental arithmetic and logical reasoning.

Feasibility of measurement. Readily studied within a laboratory setting.

Reasons for choice. Reasonable external validity particularly to classroom situations. Indirectly related to judgment and decision making tasks.

Conclusion. Difficult to draw conclusions because measures were collapsed into test batteries and individual effects were not examined.

Shanteau & Dino (1983)

DM.

Feasibility of measurement. High; tasks can be easily used in a laboratory.

Reasons for choice. Not mentioned; This study's goal was to survey a variety of tasks.

Conclusion. Noticeable decreases in subjects' puzzle solving and creativity measures.

Conclusion

Feasibility of measurement. Thinking as a construct, like stress, has not been well defined. There is a supportive literature within the areas of intelligence and aptitude testing. These tasks lend themselves to use with various stressors and can be utilized within the laboratory.

Reasons for choice. Reasonable feasibility, There is a direct application to classroom performance and an indirect application to J/DM situations.

Conclusion. Although only two studies are discussed, these studies showed decreasing performance levels with increasing stress.

Judgment and Decision Making (Including Confidence in J/DM)

Ben Zur and Breznitz (1981)

DM. Risky decision: Willingness to gamble.

Feasibility of measurement. While readily used in the laboratory, most choice situations do not involve pre-defined and knowable probabilities, thus a lack of external validity.

Reasons for choice. Easily induced in the laboratory. Subjects' data is readily compared to some "optimal selection" behavior than other less quantifiable dependent measures.

Conclusion. Authors conclude that the stress causes subjects to (a) filter out information thereby processing only a subset of the available information, (b) process information faster by spending less time on a given

piece of information, and (c) in particularly in high stress conditions, shift strategies.

They also showed that under stress subjects gave proportionally more weight to negative task dimensions and in doing so made less risky decisions.

Christensen-Szalanski (1978)

DM. Judgments and confidence about expected profit situation involving stocks and predicted market trends.

Feasibility of measurement. Moderate; lends itself to laboratory study but generality to non-monetary situations is questionable.

Reasons for choice. Optimal performance is readily quantified and there is reasonable feasibility.

Conclusion. Data are discussed within the constructs of a utility model. Results indicate that as stress increased so did subjects' confidence ratings.

Keinan, Friedland and Ben-Porath.

DM. Multiple choice analogies test.

Feasibility of measurement. Dubious construct validity: Although the authors label this multiple-choice analogies test as a decision-making task it seems more reasonable to label it a "thinking task."

Reasons for choice. Allows for multiple tests within a single experimental session.

Conclusion. Even when physical threat rather than time pressure is used, stress results in non-systematic coverage of decision alternatives (non-systematic scanning, responding before all alternatives have been considered i.e., premature closure), and responding without giving each alternative sufficient consideration (temporal narrowing).

Krueger, Armstrong, Cisco (1985)

DM. Frequency of aviator crew judgement errors.

Feasibility of measurement. Although judgement and decision making were not formally measured in this experiment, it is highly feasible to design a similar study with the aim of capturing such judgment errors.

Reasons for choice. Judgement and decision making skill critical for aviator performance.

Conclusion. There were occasional instances of judgment error in which the crew flew off well practised courses and made incorrect statements about their position relative to intersections and navigational

beacons. These errors apparently resulted from navigational miscalculations and the misreading of instruments.

Levi & Tetlock (1980)

DM. Willingness/Decision to go to war.

Feasibility of measurement. Authors used integrative complexity coding and cognitive mapping analyses to examine the statements from Japanese policy-makers regarding its 1941 decision for war. Although quite complicated this dependent measure could be used in studies of group decision-making within a laboratory setting.

Reasons for choice. Post-hoc analysis: Provided a method for studying historical data about a situation which was inherently stressful.

Conclusion. Only weak support was provided for the hypothesis that stress should produce simplified treatment of the decision situation and that integrative complexity of decisions would decrease as stress increased.

Malaterre, Ferrandez, Fleury, and Lechner (1988)

DM. Appropriateness of accident avoidance decisions.

Feasibility of measurement. Data analyzed in terms models alternate choices in accident avoidance situations.

Reasons for choice. Post-hoc analysis of accident avoidance performance.

Conclusion. Conclusions tied too closely to accident avoidance to discuss here.

Payne, Bettman, and Johnson (1988)

DM. Willingness to accept risk for financial gain.

Feasibility of measurement. Can be readily used in the laboratory.

Reasons for choice. Method allows for examination of both strategies and strategy selection. Can be generalized to other risky situations although it is questionable whether outcomes probabilities are as clear in nonlaboratory situations.

Conclusion. The results indicate that when stressed subjects processing information more rapidly, increase their selectivity, and tend to use attribute-based processing.

Ramsey, Burford, Beshin, & Jensen (1983)

DM. Unsafe work behaviors.

Feasibility of measurement. This was an extensive and realistic sample of the effects of working conditions which would be difficult to recreate in the laboratory. Other less extensive studies would be feasible.

Reasons for choice. High generality to stressful working situations.

Conclusion. Temperature above or below the preferred range of 17 - 23 degrees Celcius are correlated with a higher number of unsafe work behaviors. This inverse U-shaped function also changes as a function of workload.

Shanteau and Dino (1983)

DM.

Feasibility of measurement: Easily implemented and used with various stressors.

Reasons for choice. High external validity and high feasibility.

Conclusion. Found no effects of stress on complex decision making task.

Schwartz and Howell (1985)

DM. Optional stopping decision paradigm (hurricane tracking).

Feasibility of measurement. Moderate; the time required to unfold the decision problem could pose problems for experimental use.

Reasons for choice. Highly believable problem situation in which information comes available over the course of the problem-solving process. Subjects do not simply select the best alternative rather they must decide to act or to seek more information.

Conclusion. When stressed the graphic display of information resulted in significantly better performance than the numerical display. Also, performance improved when subjects were aided in calculating worst-case probabilities.

Wright (1974)

DM. Consumer choice (car purchase).

Feasibility of measurement. High, however the information display method could potentially force DM to use unnatural decision strategies.

Reasons for choice. High feasibility.

Conclusion. Stress caused subjects to pay more attention to negative choice attributes. Also, subjects showed dimensional selectivity: they attended to fewer relevant dimensions when making their decisions.

Zakay (1985)

DM. Nursing care decisions.

Feasibility of measurement. High; while the scenarios were artificial, the testing method is a reasonable test of the nurses judgement behaviors.

Reasons for choice. Highly important to understand the situations which produce decision strategies shifts.

Conclusion. Stress resulted in greater reliance on non-compensatory decision strategies: Important attributes are given proportionally more weight on the final decision.

Zakay & Wooler (1984)

DM.

Feasibility of measurement. High; however method might induce the use of untypical strategies.

Reasons for choice. good feasibility and reasonable external validity to other single choice selection tasks.

Conclusion. Training is ineffective if decision is made under time pressure: Time pressure negates the positive effects of training. However, it is not clear how effective was to begin with because of (a) the allotted training time was short and (b) subjects were not allowed to practice.

Conclusion

Stress has been shown to affect (a) the amount of attention and time allotted to the decision task (b) the thorough study of decision alternatives and issues affecting the selection of alternatives (dimension filtering), (c) the relative weight the decision maker places on negative versus positive expected outcomes of a given choice and (d) the choice of strategy applied to the task.

Memory

Babkoff, Thorne, Sing, Genser, Taube, and Hegge (1985)

DM. Digit recall task, serial addition and subtraction.

Feasibility of measurement. High.

Reasons for choice. Reasonable external validity particularly to classroom situations.

Conclusion. Because the various measures were analyzed as test-batteries, it is difficult to describe the specific effect of stress on any one measure.

Shanteau & Dino (1983)

DM.

Feasibility of measurement. Authors used simple list-learning paradigm to study immediate and long-term recall.

Reasons for choice. Memory as seen as an essential component of most decision making tasks.

Conclusion. Stress produced small decrements in performance particularly in the delayed recall condition. However, no substantial changes in serial-position curve shape were observed.

Krueger, Armstrong, Cisco (1985)

DM. 6, 8, or 10 digit alphanumeric recall task.

Feasibility of measurement. High; employed standard memory tasks with a strong supporting literature.

Reasons for choice. To-be-recalled digits were similar to military map grid coordinates: Externally valid to such a task.

Conclusion. Authors did not discuss the results of this measure however they stated it was a good indicator of stress.

Conclusion

Feasibility of measurement. High.

Reasons for choice. Obvious connections to judgement and decision making situations.

Conclusion. This area has not been explored in great detail and the results are quite varied. This seems in part to be a function of the wide range of theoretical perspectives used when conducting the original work.

Affect (As It Is Related to Above Cognitive Functions)

Babkoff, Thorne, Sing, Genser, Taube, and Hegge (1985) (Physiological Variables; Mood Quest)

DM. Adjective checklist of current feelings, Psychiatric symptoms test.

Feasibility of measurement.

Reasons for choice. Interesting to relate stress to affect and affect to decision making.

Conclusion. Paper offers little discussion of the affect measures by themselves so direct conclusions about these measures cannot be drawn.

Smith (1985)

DM. Air traffic controller performance.

Feasibility of measurement. Not applicable.

Reasons for choice. High external validity.

Conclusion. Paper reviews numerous studies of stress effects on air traffic controller (ATC) performance. The author's general conclusion is that there is little evidence to suggest that ATC's experience inordinate amounts of stress on the job.

Conclusion

Feasibility of measurement. Moderate; because affect itself is a construct requiring its own definition, it has been difficult to settle on agreed-upon measures or a research paradigm.

Reasons for choice. Stress is accepted as having a large influence on affect; affect is also assumed to be an indicator of stress.

Conclusion. The few studies discussed here draw diverging conclusions.

Learning

Hogarth, Gibbs, McKenzie, and Marquis (1990)

DM. Multiple cue probability learning.

Feasibility of measurement. Highly feasible.

Reasons for choice. Learning an obvious feature of many occupations.

Conclusion. "Expectingness" has an effect on performance (e.g., "performance is an inverted U-shaped function of existingness").

Rothstein (1986)

DM. Multiple cue probability learning.

Feasibility of measurement. Highly feasible.

Reasons for choice. Learning an obvious feature of many occupations.

Conclusion. "Time pressured individual tends to be erratic even while implementing correct policy." (Note: This result contradicts the "narrowing" hypothesis.)

Conclusion

Feasibility of measurement. High; learning has been studied in a wide variety of methods.

Reasons for choice. Obvious relevance to many cognitive, behavioral activities.

Conclusion. The two studies reported were conducted within the lens model framework, suggesting its utility for this topic.

Chapter VI
Results of Empirical Studies (Grouped According to Stressor)

The results of research are grouped in terms of the stressors employed for the reason that it is the simplest method. Other choices lead to undue complexity because of overlap of categories, fuzzy boundaries, and/or multiple listings.

Sleep Loss

Babkoff, Genser, Sing, Thorne, and Hegge (1985)

Results/conclusions. "Response lapses increased as a function of sleep loss and were fitted best by a composite equation with a major linear component and a minor rhythmic component. Response accuracy decreased as a function of sleep loss, with the rate of decrease being greater for nonwords than for words. Although d' was higher for right visual field (RVF), it decreased for both fields almost linearly as a function of sleep deprivation. The rate of decrease for RVF stimulation was greater than for left visual field (LVF) stimulation. [Beta] did not change monotonically as a function of sleep loss, but showed strong circadian rhythmicity, indicating that it was not differentially affected by sleep loss per se" (p. 614).

Comments. This article is one of two (see also Babkoff, Thorne, Sing, Genser, Taube, and Hegge, 1985) that examines the effects of sleep loss as a stressor on the performance of a specific cognitive task. .

Babkoff, Thorne, Sing, Genser, Taube, and Hegge (1985)

Results/conclusions. "As sleep deprivation continued, the average time on task increased at an accelerating rate. The rate of increase differed among tasks, with longer tasks showing greater absolute and relative increases than shorter ones. Such increases confound sleep deprivation and workload effects. In this article, we compare the advantages and disadvantages of several experimental paradigms; describe details of the present design; and discuss methodological problems associated with separating interactions of sleep deprivation, workload, and circadian variation with performance" (p.604).

Comments. The participants in this study were assessed with a substantial test battery. In this article, however, the authors chose to report only the overall time it took to perform tasks of various kinds, and did not report more specific measures of performance.

Shock

Bacon (1974)

Results/conclusions. "Results indicate that arousal narrows the range of cues processed by systematically reducing responsiveness to those

aspects of the situation which initially attract a lesser degree of attentional focus. This stimulus loss under arousal represents, independently of any response criterion changes, an actual diminution in the Ss' sensitivity. In addition, it seems that arousal mediates its effect not so much by impeding the initial sensory impression as by affecting the capacity limitations and attentional control processes operating within short-term memory" (p. 81).

Comments. This study is one of a few that uses signal detection theory (cf. Babkoff et al., 1985) to distinguish sensitivity from response bias in performance of a task under stress. It may even be unique in briefly discussing the possibility that stress affects short-term memory processes rather than perceptual encoding processes.

Friedland and Keinan (1982)

Results/conclusions. The empirical evaluation of "graduated fidelity training" whereby the trainee is exposed to gradually increasing stressor intensities . . . suggested that it is potentially more effective than high fidelity training. However, two conditions are necessary for the realization of this potential effectiveness. First, the trainee must be informed about the upper limit of the stressor intensity which he might encounter in the course of training. In the absence of such information, graduated fidelity training might become highly ineffective. Second, the trainee has to perceive high quality performance as being instrumental for the removal or attenuation of stressors" (p. 41).

Comments. This article is grounded in theory and is one of a small number of studies that compare ways of training people to perform a task under stress. It is uncertain whether the methods explored and the results obtained may be generalized to other tasks and stressors.

Keinan and Friedland (1984)

Results/conclusions. "The results pointed to three conditions for the enhancement of training effectiveness: (a) minimal interference of exposure to stressors with task acquisition, (b) familiarity with stressors characteristic of the criterion situation, and (c) absence of unrealistic expectations about future stressors. However, none of the five training procedures meets all three conditions. Implications for the design of procedures whereby persons can be trained to perform proficiently under stress are discussed" (p. 185).

Comments. This article (see also Friedland & Keinan, 1982) is one of a small number of studies that compare methods of training people to perform a task under stress. The comparison of five different procedures, which yielded ambiguous results, demonstrates the complexity of studying decision making and training in decision making under stress.

Keinan, Friedland, and Ben-Porath (1987)

Results/conclusions. "Stress was found to induce a tendency to offer solutions before all decision alternatives had been considered and to scan such alternatives in a nonsystematic fashion. In addition, patterns of

alternatives-scanning were found to be correlated with the quality of solutions to decision problems" (p. 219).

Comments. This article, along with Keinan (1987), chiefly explores the hypothesis that previous studies of decision making under stress using time pressure as the stressor have proven inconclusive due to a potential confound, namely "that a complete, systematic scanning of all available alternatives, and the investment of sufficient time in the evaluation of each, might be physically impossible when time is severely limited" (pp. 221-222). Thus previous investigators have interpreted their results as being due to stress when in fact the results may be attributable purely to time limitations.

Dangerous Environments

Baddeley (1972)

Results/conclusions. "Evidence on human performance in dangerous environments is reviewed and suggests that danger reduces efficiency, except in the case of experienced subjects. Perceptual narrowing is shown to be one source of decrement. It is suggested that danger increases the subject's arousal level which influences performance by producing a narrowing of attention. The nature of the performance decrement and of adaptation to danger are discussed in this context" (p. 537).

Comments. This review of over twenty-five experimental and theoretical articles concentrates mostly on studies of dangerous environments such as deep-sea diving but also draws parallels from research on performance in other dangerous environments.

Weltman, Smith, and Egstrom(1971)

Results/conclusions. "The chamber group showed significantly higher anxiety scores and also a significantly higher heart rate throughout the experiment. There was no difference between the groups with regard to correct Landolt detections, although the chamber group responded somewhat slower. Peripheral detection, however, was severely and significantly degraded in the chamber group. It was concluded that perceptual narrowing had been demonstrated as a result of psychological stress associated with exposure to the 'dangerous' pressure-chamber" (p. 99).

Comments. This article demonstrates the effects of perceived threat on the performance of a task. None of the dependent measures was cognitive in nature.

Idzikowski, and Baddeley (1983)

Results/conclusions. A review article. "In this chapter we have considered the effect of fear and danger on performance, subjective state, and bodily reactions. We have concentrated primarily on data provided by experiments conducted in controlled dangerous environments, primarily

parachuting and diving, though available evidence from the results of natural disasters and war has also been examined. The evidence suggests that when a situation has induced fear in an individual (as measured by subjective and physiological responses), then a deterioration in the efficiency of performance can be expected, especially in tasks involving sensory-motor skill or divided attention. The findings are interpreted within the general arousal framework, which assumes an inverted-U relationship between arousal and performance" (P. 141).

Comments.

Time Pressure

Ben Zur and Breznitz (1981)

Results/conclusions. "The results show that subjects are less risky under High as compared to Medium and Low time pressure, risk taking being measured by choices of gambles with lower variance or lower amounts to lose and win. Subjects tended to spend more time observing the negative dimensions (amount to lose and probability of losing), whereas under low time pressure they preferred observing their positive counterparts. Information preference was found to be related to choices. Filtration of information and acceleration of its processing appear to be the strategies of coping with time pressure" (p. 89).

Comments. Ben Zur and Breznitz's results are comparable to those of Wright (1974), who employed a multi-attribute decision making paradigm. Based on their results, Ben Zur and Breznitz conclude with an implicit recommendation about the manipulation of time pressure. "Thus, the method of obtaining information about dimensions according to preferences is of greater significance in analyzing information processing prior to decision when the extreme values of the time pressure continuum are investigated" (p. 103).

Payne, Bettman, and Johnson (1988)

Results/conclusions. "A computer simulation using the concept of elementary information processes identified heuristic choice strategies that approximate the accuracy of normative procedures while saving substantial effort. However, no single heuristic did well across all task and context conditions. Of particular interest was the finding that under time constraints, several heuristics were more accurate than a truncated normative procedure. Using a process-tracing technique that monitors information acquisition behaviors, two experiments tested how closely the efficient processing patterns for a given problem identified by the simulation correspond to the actual processing behavior exhibited by subjects. People appear highly adaptive in responding to changes in the structure of the available alternatives and to the presence of time pressure. In general, actual behavior corresponded to the general patterns of efficient processing identified by the simulation" (p. 534).

Comments. This article is unique in its use of a computer simulation as an aid for studying strategy selection in decision making. The within-subjects design strengthens the credibility of the conclusions reached and their representativeness of processes occurring outside the laboratory. The conclusion that "people appear highly adaptive" in the "presence of time pressure" is therefore significant.

Rothstein (1986)

Results/conclusions. "Lens model analyses indicated that cognitive control deteriorated under time pressure while cognitive matching remained unchanged. This effect was limited to complex cue-criterion environments containing curvilinear forms. The results suggest that the time pressured individual tends to be erratic even while implementing correct policy" (p. 83).

Comments. This article explores the effects of time pressure on judgment in the context of the lens model (see also Schwartz and Howell, 1985). It is significant because the method employed separates the change in judgment policy from the consistent execution of the policy.

Schwartz and Howell (1985)

Results/conclusions. "Display formation had a significant effect when time pressure was involved: subjects reached earlier and better terminal decision under the graphic than the numerical format. . . . The difference reduced to nonsignificance under self-pacing . . . although significant improvements were obtained by use of a simple aiding device (calculation of worst-case probabilities). Results are generally consistent with Hammond's cognitive consistency [sic] theory" (p. 433).

Comments. This article is one of only a small number that examine decision making under more dynamic task conditions. In addition, this article studies the relation between time pressure stress, and display format (graphic vs. numeric) on decision making.

Wright (1974)

Results/conclusions. "Data usage models assuming disproportionately heavy weighting of negative evidence provided best-fits to a significantly higher number of subjects in the high time pressure and moderate distraction [noise] conditions. Subjects also attended to fewer data dimensions in these conditions" (p. 555).

Comments. The main finding of this study, that subjects under time pressure give more weight to negative information, is corroborated by Ben Zur and Breznitz's (1981) results from a risky choice task.

Zakay and Wooler (1984)

Results/conclusions. "It was found that training resulted in more effective decision making only under the 'no time pressure' condition. Under time pressure the training did not improve the quality of decision making at all, and the effectiveness of the decisions was significantly lower

than under no time pressure. It was concluded that specific training methods should be designed to help decision makers improve their decisions under time pressure" (p. 273).

Comments. The topic of this article (training people to make decisions under stress) is of critical importance to the military, yet apparently there is little or no research on the topic; but see Keinan, 1982; Keinan & Friedland, 1984.

Unrepresentative Training

Friedland and Keinan (1982)

Results/conclusions. The empirical evaluation of "'graduated fidelity training' whereby the trainee is exposed to gradually increasing stressor intensities . . . suggested that it is potentially more effective than high fidelity training. However, two conditions are necessary for the realization of this potential effectiveness. First, the trainee must be informed about the upper limit of the stressor intensity which he might encounter in the course of training. In the absence of such information, graduated fidelity training might become highly ineffective. Second, the trainee has to perceive high quality performance as being instrumental for the removal or attenuation of stressors" (p. 41).

Comments. This article is grounded in theory and is one of a small number of studies that compare ways of training people to perform a task under stress. It is uncertain whether the methods explored and the results obtained may be generalized to other tasks and stressors.

Fatigue

Christensen-Szalanski (1978)

Results/conclusions. "A manipulation check revealed failure of the task to produce fatigue. . . . [although] all participants reported that they felt more mentally fatigued after each 3-hr session than when they began. Thus, an alternative approach to fatigue is afforded by comparing the data from the first half of each of the two sessions session with those of the second half. . . . the results were significant in the predicted direction" (p. 316). That is, participants were significantly less confident in the accuracy of their responses when they reported being more fatigued.

Comments. Although the main concern of this article was not the effect of stress (or fatigue, as manipulated here), participants were less confident in their answers when fatigued.

Information Processing/Memory Load

Hamilton (1982)

Results/conclusions. Hamilton favors making a "distinction among types of stress, particularly between stress as an effect and stress as an agent" (p. 105). He argues "in support of an information processing concept of stress as an agent, where stress as an effect is seen as the consequence of the type and amount of information processing mediated by stressors, which contain and generate stressful information" (p. 105). Hamilton also distinguishes among physiological, cognitive, and psychogenic stressors. His main point about cognitive stressors concerns their effect on overloading short-term or working memory. Because all information used to guide behavior resides in working memory, it follows that stress information can overload working memory's limited capacity. "By definition, cognitive stressors are those cognitive events, processes, or operations that exceed a subjective and individualized level of average processing capacity" (p. 109). This overload can result from a person's experience or inexperience with particular stimuli. Thus, "an event does not become a stressor until a cognitive processing system has identified it as such on the basis of existing long-term memory data" (p. 117).

Comments. This article covers more than forty articles related to information processing and stress. Hamilton's idea is that stress can overload the limited capacity of working memory and thus degrade cognition and behavior. Hamilton does not cover the facilitation of processing under stress, however; but concentrates on its negative effects.

Note

This stressor has been investigated in the human factors literatures as much or more than any other.

Noise

Hockey (1970)

Results/conclusions. "The aims of this chapter are twofold; firstly, to attempt an integrated survey of research findings in the area of stress and performance and, secondly, to propose alternative methodological and theoretical approaches to the experimental study of stress effects in cognition. In reviewing the literature I have concentrated on two main areas of skilled performance, sustained attention and memory. This is primarily because most work has been done in these two fields and the findings are therefore more reliable. In addition, however, and this may be no accident, these two components may be considered as, in some ways, primary in the organization of skilled behavior" (pp. 141-142).

In addition to pointing out the problems caused by referring to stress as both cause and effect as early as 1970, Hockey was emphasizing the "widespread and largely uncritical acceptance of the Yerkes-Dodson law in

human stress research. I do not want to object to its failure to describe the effects of stress adequately, but it blinds us to the recognition of more fundamental changes in functioning" (p. 144). More important questions are "What changes underlie the observations embodied in the Yerkes-Dodson law?" "Why are high levels of arousal bad for performance?" "What makes a task difficult?" In general these questions have been side-stepped in favour of circular reasoning and naive operational definitions" (p. 144).

Hockey makes two recommendations: "adopt an approach of examining the detailed effects of a single stress across a range of tasks" (p. 170), develop "a realistic functional model of cognitive behaviour . . . [with a] closer link with the mainstream theory" (p. 170).

Comments. This article reviews over one hundred articles related to the effects of stress on cognition and behavior. Much of the material reviewed is now dated and restricted to stimulus response studies, but Hockey makes important arguments concerning the Yerkes-Dodson law and suggestions for future research.

Koelega, Brinkman, and Bergman (1986)

Results/conclusions. Although a review, the conclusions are quoted here because they reflect the ambiguity and confusion produced by the research.

From a literature review of the effects of noise upon visual vigilance performance, Koelega and Brinkman (1986) concluded that one cannot generalize from the existing data, and that many studies were methodologically flawed. Ninety-eight studies published since 1960 were reviewed, and 21 with similar task demands were examined in detail. Diverse results were reported, but most commonly "negative" results; that is, no effect of noise was found.

It is possible that this general lack of a noise effect can be attributed to a common failure of analytical approaches. The measure of performance most often used in vigilance experiments has been the mean percentage of signals detected in each 20-min, 30-min, or 40-min period. It has been observed by some investigators (e.g., Sanders, 1961; Wokoun, 1969) that noise sometimes has profound effects on performance variability than can far overshadow and mask mean differences. More than two decades ago, some authors suggested that averaging over periods of 10 min or more may be too coarse a way to handle the data (Jerison, 1963; McGrath, 1963). In spite of this admonition, only a few investigators have used a more fine-grained analysis of the effects of noise (Fisher, 1972, 1973; Salamé and Wittersheim, 1978; Woodhead, 1964). None of these, however, utilized a simple sensory monitoring experiment.

Investigators have more recently emphasized the desirability of meticulously examining the details of the results (Broadbent, 1976; Jones, 1983, Smith, Jones, & Broadbent, 1981). Goldstein and Dejoy (1980) stated that an overreliance on gross overall measures of performance has impeded progress toward understanding the effects

of noise on performance. Furthermore, based on the literature review mentioned previously, it appears that there is as yet no study using a multivariate analysis of the effects of noise in a visual monitoring task, although it has been noted (Jerison, 1977) that one should be wary of bivariate tests in vigilance experiments. Therefore, the present authors decided to employ such an analysis on data collected in a between-subjects design, manipulating both frequency and regularity of noise stimuli occurrence. The hypothesis was that inspection of the microstructure of responding would reveal effects that are absent in gross response indices. (pp. 581-582)

In conclusion, the present study offers some evidence that the usual way of analyzing data from vigilance experiments may veil the effects of independent variables such as noise; that expectancy theory cannot explain the effects of noise on vigilance performance; and that sex differences in monitoring performance may be revealed in some studies, but not in others. (p. 591).

Hockey's paper was not cited.

Koelega and Brinkman (1986) had earlier concluded on the basis of their extensive review that "we know nothing about the effects of variable noise on sustained attention" (p. 465).

In view of these remarks on the state of noise as a stressor we omit further discussion of it.

Threat

Janis (1983)

Political Crisis

Levi and Tetlock (1980)

Results/conclusion. "Previous studies have found that the cognitive performance of government decision-makers declines in crises that result in war. This decline has been attributed to crisis-produced stress which leads to simplification of information processing. The present study tested the disruptive stress hypothesis in the context of Japan's decision for war in 1941. Two content analysis techniques . . . were used to analyze the translated records of statements by key Japanese policy-makers. Comparisons between statements made in the early and late periods of the 1941 crisis yielded only weak evidence of cognitive simplification. Interestingly, however, the social context in which statements were made significantly affected the complexity of cognitive performance: Statements made in Liaison conferences (in which policies were formulated) were significantly less complex than statements made in Imperial conferences (in

which policies were presented to the Emperor for approval). Theoretical and methodological implications of the results were discussed" (p. 195).

Comments. This study, although conducted after events took place, is unique in that it explores the effects of stress on actual political decision makers.

Accident Avoidance

Malaterre, Ferrandez, Fleury, and Lechner (1988)

Results/conclusions. Subjects' estimates of the minimum distance at which they could turn to avoid an obstacle were significantly smaller than their estimates of the distance at which they could brake to avoid an obstacle. This suggests that a lateral movement might be the best accident-avoidance procedure, yet the available literature on the subject shows that people rarely do anything other than brake, and in many cases are not even aware of an alternative course of action.

Comments. Stress was not directly manipulated in these experiments, although it presumably was a part of the experimental situation. The effects of stress per se on the behavior under study are not explored in detail.

Heat

Shanteau and Dino (1983)

Results/conclusions. "Under stress, subjects showed decreases in creativity, lower reliability in decision making, and shifts in serial-position effects. In contrast, stress had little impact on verbal problem solving, general intelligence, or decision complexity" (p. 362).

Comments. This study examined the effects of stress on several problem-solving and decision making tasks. The finding of decreased creativity under stress is noteworthy.

Learning

Hogarth, Gibbs, McKenzie and Marquis (1990)

Feedback from the outcomes of decision confounds two kinds of information. One concerns the nature of the underlying decision-making task; the second how well the decision maker has performed in the task. Within the context of learning a repetitive decision-making task, we examine the effects of *exactingness* or the extent to which deviations from optimal decisions are punished. We hypothesize that exactingness has both positive and negative effects on performance and that performance is an inverse-U shaped function of

exactingness. In addition to exactingness, we also consider the effects of incentives and argue that these accentuate the positive and negative effects of exactingness. This leads to predicting specific interactions between exactingness and performance. These predictions, as well as several related issues, are examined in a series of five experiments in which exactingness is manipulated by adjusting the coefficient of a squared-error loss function. Results include the findings that (a) performance is an inverted-U shaped function of exactingness, (b) performance is better under incentives when environments are lenient but not when they are exacting, (c) the interaction between exactingness and incentives does not obtain when an incentives function fails to discriminate sharply between good and bad performance, and (d) when the negative effects of exactingness on performance are eliminated, performance increases with exactingness. We conclude by discussing our work from both theoretical and practical perspectives and make suggestions for further research. (Abstract)

High Pressure Work Situation

Smith (1985)

Results/conclusions. We include this article even though it does not directly address the issue of the effects of stress on judgment and decision making because the task of aircraft controller is assumed to involve considerable stress. Contrary to this assumption, Smith concludes that: "there is little evidence to support the notion that ATC's are engaged in an unusually stressful occupation. This is not to say that ATC's never encounter stress on the job; however, it does appear that this is the exception rather than the rule . . . The demands of air traffic work do not appear to place unusual stress on ATC'S; this professional group appears quite capable of handling requirements of the job without distress. The notion that the occupational group is being pressed to the psychological and physiological limit is clearly unjustified" (pp. 106-107).

Chapter VII Conclusions

No defensible consensus, readily justified on empirical grounds, arises from our examination of these articles. No general principle explaining the effect of stress on judgment and decision making is supported by a conclusive set of empirical studies. Although it has been demonstrated that stress impairs, enhances, and has no effect on cognitive activity on some occasions, with some people, no generalization over conditions or people is secure..

Empirical Work

The empirically based articles describe a wide variety of stressors, but time pressure, noise, and electric shock were usually manipulated experimentally. Stressors that appeared in observational studies are heat and emergency operations of various kinds; for example, controlling air traffic or directing a helicopter simulator through difficult maneuvers. Experimental studies far outnumber observational or field studies.

Theoretical/Review Work

The theoretical work examined also failed to yield a consensus on the causes or effects of stress on judgment and decision making behavior. Theories are largely informal; hypotheses are rarely rigorously formulated.

Nor do the review articles aid in establishing coherence among the articles included. Review articles cover work ranging from performance in dangerous environments such as deep-sea diving to critiques of the noise-as-a-stressor literature. Empirical studies are not organized in relation to theories.

Unresolved Issues

1. Does stress cause "narrowing"? This question has received considerable attention, and the answer has generally, but not always been, "Yes" (see Allnutt, 1987; Bacon 1974; Baddeley, 1972; Hockey, 1970; Keinan, 1987; Keinan, Friedland, & Ben-Porath, 1987; Weltman, Smith, & Egstrom, 1971; Wright, 1974), and its truth seems to be taken for granted. The "narrowing" hypothesis should receive a high priority in future systematic research.

2. The utility of the Yerkes-Dodson (inverted-U) arousal law is increasingly being questioned. Does it directly apply to judgment and decision making under stress? If so, which cognitive processes are affected, and in what way?

3. How is a specific environmental stressor (e.g., time pressure) to be calibrated on a stressor scale? How is subjective stress to be calibrated so that meaningful comparisons can be made between studies? Without such calibrations it will be difficult to ascertain the conditions under which environmental stress produces subjective stress, to determine whether these conditions involve high or low stress, and to determine when (or whether) these conditions lead to impaired, enhanced, or unchanged

performance. Until such work is done, no definite conclusions can be reached about prior research because it is unclear where to place each study's stress condition on the stressor scale. Similarly it is difficult to ascertain the location of the subject's response on the stressor scale.

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